Printed on thin paper for overseas circulation

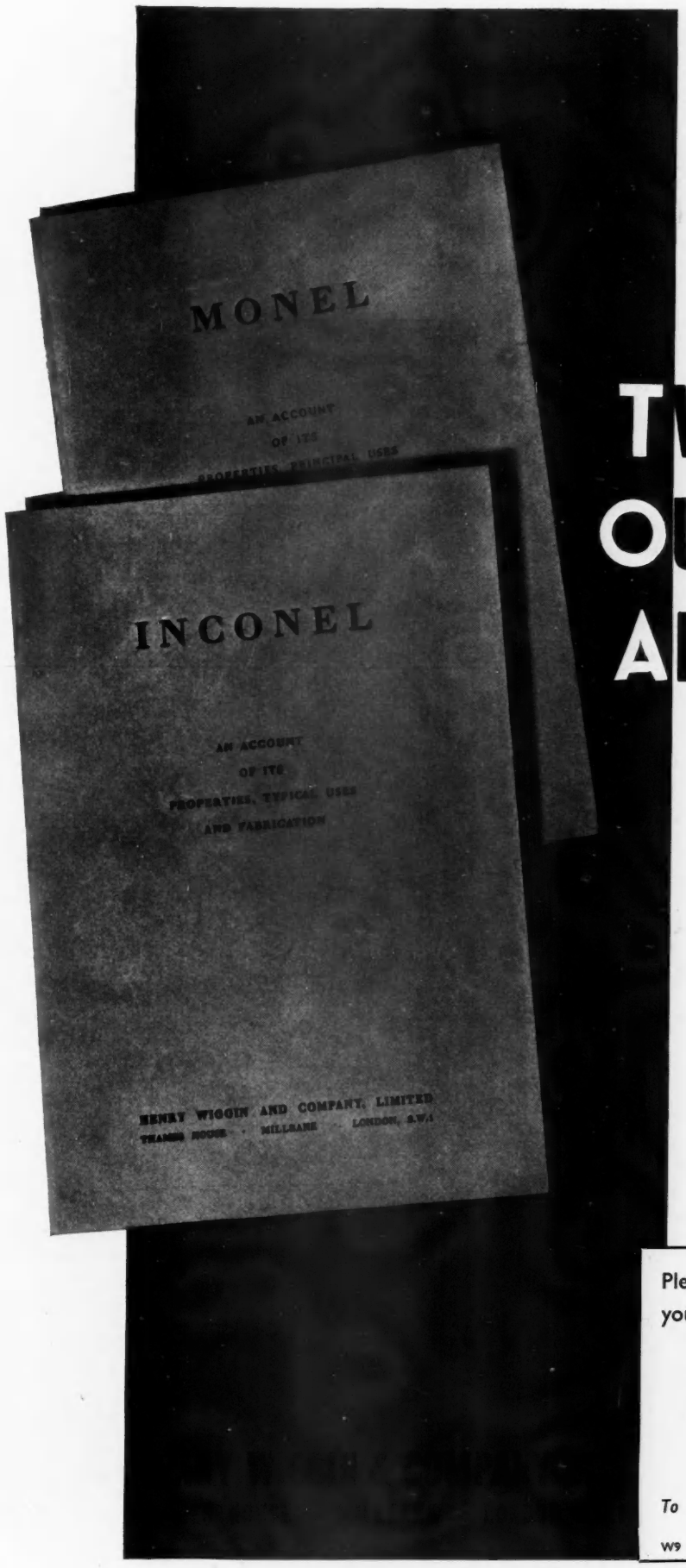
The Engineer

Vol. CLXIX.—No. 4396 28, ESSEX ST., STRAND, LONDON, W.C.2 APRIL 12, 1940

Established 1856 Price One Shilling, by Inland Post 1s. 3d. Registered as a Newspaper

Engineering Library

APR 30 1940



TWO OUTSTANDING ALLOYS

The two publications illustrated deal with the properties, fabrication and uses of two important engineering alloys — Monel and Inconel.

Monel is a general purpose alloy combining great strength with pronounced resistance to corrosion. Various grades are made to meet specialised requirements.

Inconel, though a newer material, has been used for nearly a decade. Its main uses are due to its high resistance to corrosion, tarnishing and oxidation under elevated temperatures.

Copies of these publications will be sent, free of charge, on receipt of the coupon below duly completed.

Please send me, free of charge, copies of your publications MX8 and MX9.

Name.....

Address .....

.....

To **HENRY WIGGIN & COMPANY LTD.**
Thames House, Millbank, London, S.W.1

W9

28" REVERSING MILL

Producing Rounds, Squares, Flats, Angles Channels, etc.

The most up-to-date plant for a varied product: Supplied complete with all

ELECTRICAL EQUIPMENT

LAMBERTON

COATBRIDGE SCOTLAND

MAKERS of ROLLING MILL PLANT

CLIMAX

LOW VELOCITY

FANS

Dependable, Economical, and Surprisingly Quiet

ALLDAYS & ONIONS LTD

GREAT WESTERN WORKS
BIRMINGHAM 11

'Phone: Victoria 2251–4 Birmingham.
'Grams: Alldays, Phone, Birmingham.

For Lists apply Dept. FA

9 VICTORIA STREET
LONDON, S.W.1

'Phone: Abbey 7184.
'Grams: Typhoon, Sowest London.

A Seven-Day Journal

The Federation of British Industries

THE annual general meeting of the Federation of British Industries was held on Wednesday, April 10th, and Lord Dudley Gordon was elected President. Mr. Peter Bennett, who is now Director-General of the Production of Tanks and Mechanical Transport at the Ministry of Supply, retires after having held office as President of the Federation for two years. In an interview, Lord Dudley Gordon said that British industry, by closing its ranks and presenting a united and well organised front, would make certain of success in the opportunities for collaboration that now appeared. Notably, the formation of the Export Council, which followed suggestions made by an F.B.I. deputation to the Prime Minister, gave scope for planned co-operation. Lord Dudley Gordon pointed out that on the Export Groups, formed at the initiative of the Export Council, fell the task of organising the export drive within the particular individual industry concerned. To that end, he said, it would be necessary to secure in any particular trade and between individual firms a degree of co-operation rarely achieved under conditions of peace. That was a duty which he felt certain would be efficiently performed by the industrial trade associations of the country. The Federation was actively assisting its members in the formation of these groups and was giving advice on procedure and on the appointment of chairmen and secretaries for particular groups, and in certain cases was prepared to provide the necessary secretariat. Continuing, he said that one of the most useful achievements of the Federation itself was the establishment of the Anglo-French Industrial Council, whose object would be to secure the closest possible co-operation between organised industry in Britain and in France.

A Coal Production Council

ON Friday, April 5th, it was officially announced by the Mines Department, that with a view to securing a further increase in coal exports to Allied and other countries, as well as maintaining supplies for all essential home purposes, the Secretary of Mines, Mr. Geoffrey Lloyd, had set up a Coal Production Council, to promote a substantial increase in the production of coal, and for this purpose to collaborate with representative bodies of owners and of workmen, and with the Government Departments concerned. Lord Portal has consented to be the chairman of the new council, which will be composed of three representatives from the workmen's side, and three representatives from the owners' side of the Joint Standing Consultative Committee, together with representatives of the Ministries of Transport, Shipping, and the Mines Department. The membership of the Council is as follows:—Chairman, Lord Portal; Mr. Will Lawther, President of the Mineworkers' Federation of Great Britain and a member of the T.U.C. General Council, Mr. James Bowman of the Board of Mining Examinations, Mr. Ebby Edwards, Secretary of the Mineworkers' Federation, Sir Evan Williams, President of the Mining Association of Great Britain, Sir Walter Benton Jones, Chairman of United Steel Companies, Ltd., and Vice-President of the Mining Association of Great Britain, Mr. W. A. Lee, director of the Mining Association of Great Britain, Mr. Christopher S. Hurst, Secretary and Controller of the Coal Commission, Mr. Reginald H. Hill, Principal Assistant Secretary of the Finance and Secretarial department of the Ministry of Transport, and Mr. T. G. Jenkins, Second Secretary of the Ministry of Shipping. We learn that the first meeting of the Council took place early in the week, and that it is the intention of Lord Portal to tour the coalfields immediately. All communications to the Coal Production Council should be addressed to the Secretary, Coal Production Council, c/o Mines Department, Dean Stanley Street, Millbank, London, S.W.1.

Reyrolle and Co., Ltd.

IN the course of his chairman's speech at the thirty-sixth annual general meeting of A. Reyrolle and Co., Ltd., held at Newcastle-upon-Tyne on Thursday, April 4th, Mr. Norbert Merz, made reference to the additions to the works and the new machinery which had recently been installed, and which would, he said, add to the production facilities of the firm. The improvements in the design of switchgear which had been or were being brought into effect demanded, he said, greater accuracy in production, which in turn called for a larger number of precision machine tools. Such tools were also required for the special work which the company had undertaken as distinct from its normal productions. Consequent upon an agreement which had been entered into with the National Physical Laboratory, and for dealing with the extra load of the works, orders have been placed for additional testing plant. He was glad to say that the firm of C. A. Parsons and Co., Ltd., in which the company had an interest had had a good year, and co-operation in many directions had proved valuable. The Parolle Electric Plant Company had also extended largely its sphere of action, and had undertaken important contracts, including some of the power plants at new Government factories. The company had also made a small capital investment in a company manufacturing switchgear in France, with which it had been associated for many years with much mutual benefit.

The Institution of Chemical Engineers' Luncheon

AT the luncheon of the Institution of Chemical Engineers, which was held in London on Friday, April 5th, Mr. E. L. Burgin responded to the toast of "His Majesty's Ministers" proposed by Mr. C. S. Garland. In proposing this toast, Mr. Garland pointed out that at the present time the Ministers of the Crown needed our utmost good will and support, and that they deserved much gratitude for the good work they had done to date. He spoke of the difficulty of Mr. Burgin's task in fulfilling the demands of industry in this country whilst at the same time keeping closely in touch with the requirements of our overseas markets. Replying to the toast, Mr. Burgin referred to the amazing advances made in chemical engineering during the past twenty-five years and recalled the tremendous task which Lord Moulton had had to face when he was called upon to create a chemical industry a quarter of a century ago. With the outbreak of this war the country had at its disposal the records of twenty-five years of extensive study and application. He considered that our chemical and allied industries at present compared favourably with those of any country in the world in both the standard of knowledge and firm patriotism. As Minister of Supply he said that now was the critical time to throw all our energies into the nation's interest to increase production. He appealed to the whole of industry to make its maximum effort to increase the tempo of production now and look after the hereafter by making certain of the present. Mr. A. Vyvyan Board proposed the toast of the Institution, and in his response the President, Mr. F. Heron Rogers, referred to its growing strength and the courses now available for prospective members and graduates. Replying to Sir Harold Hartley's toast of the guests, Rear-Admiral B. A. Fraser, the Third Sea Lord and Controller of the Navy, assured his listeners that there was no lack of harmony in his Department and a close co-operation with industry was constantly maintained. Following a number of amusing anecdotes, he paid tribute to the Merchant Service and spoke of the mutual respect which exists between it and the Royal Navy.

The Unemployment Returns

ACCORDING to the returns issued on April 3rd by the Ministry of Labour and National Service there was a very substantial improvement in employment between February 12th and March 11th. Between those two dates the number of unemployed persons on the registers of employment exchanges in Great Britain fell by 382,887. As compared with March, 1939, this was a reduction of 605,716. A large part of the increase in employment was because of the improvement in weather conditions, but in addition there was a general increase in industrial activity from other causes. Between February 12th and March 11th there was a fall in the numbers unemployed in practically every industry. The improvement in employment was most marked in building, public works contracting, and agriculture and horticulture. The other principal industries in which employment increased included coal mining, brick making, stone quarrying, iron and steel and metal goods manufacture, engineering, shipbuilding and repairing, road transport, tailoring, printing and bookbinding, the distributive trades and hotel and boarding house service.

Civil Aviation in Wartime

ON Thursday, April 4th, Sir Kingsley Wood performed one of his last duties as Secretary of State for Air in receiving a deputation from the Civil Aviation section of the London Chamber of Commerce. A memorandum was submitted dealing with a number of points, including the supply of civil transport aircraft and the development of new services, both during and after the war. The appointment of the Civil Aviation Advisory Committee and the nature of its work was also raised. Replying to the deputation, Sir Kingsley Wood said that the policy of the Air Ministry was to support and encourage civil aviation within the limitations which had necessarily been imposed by the war. The empire services had been carried on without interruption, and New Zealand would this month be linked thereto by a weekly service. Pre-war frequency on the South African service would be resumed that week and it was hoped to start a service to Lisbon in May. The Air Ministry was alive to the desirability of transatlantic services, but it felt that the North Atlantic service must have priority. There had been no option at the beginning of the war, he continued, but to stop development work on large new civil aircraft designs. It was not possible to divert designers and draughtsmen to prepare designs for purely civil types. In any case such steps would be valueless unless the development work could be followed by quantity orders. But in connection with military requirements the needs of civil aviation were being borne constantly in mind. For example, to meet requirements in troop carriers orders had been placed with the De Havilland company for a variation of the "Flamingo" civil type rather than for a new military design, and when these requirements had been met the company would be able to resume the manufacture of the civil type. It had also to be remembered that all developmental research and a great deal of specific research were common in result to both military and civil aviation. Steps would be taken to ensure that civil aviation would have the benefit of the research work that was being carried on in Government establishments and at aircraft manufacturing firms. It was with these ends in view that it was proposed to establish a Civil Aviation Advisory Committee which would plan for the future, so that with the advent of peace the aircraft industry would be able to undertake a rapid and confident civil aviation expansion programme.

Marconi Memorial at the Needles

A MEMORIAL stone in grey Cornish granite has been erected on ground adjacent to the site of the original Royal Needles Hotel, Alum Bay, in the Isle of Wight, to mark the position occupied by the first permanent wireless station. The suggestion that such a memorial should be erected was made in 1938, and the memorial has just been completed and is now open for public inspection. The Marconi wireless station at the Royal Needles Hotel holds an honourable place in the history of wireless because it was here, after a few experiments on Salisbury Plain and other places, that the late Marchese Marconi and the engineers of Marconi's Wireless Telegraph Company, Ltd., put up the first permanent wireless station and carried out the series of experiments which placed wireless communication on a firm foundation. Using a steamer—the "Mayflower"—in order to enable them to carry out experiments at various distances, Marconi and his assistants at this station tested one piece of apparatus after another and so gradually extended the distance over which signals could be transmitted and received. The range covered was quickly increased up to 40 miles, thus opening up the prospect of the greater achievement in spanning the Atlantic from the Poldhu wireless station a few years later, in 1901. From December, 1897 to May, 1900 Marconi and his British collaborators carried out at the Needles a series of experiments forming important pioneer work in the development of wireless communication. Messages were at first exchanged with a tug in Alum Bay; then with Bournemouth, 14 miles distant; next with Poole, 18 miles away; and later with ships 40 miles out to sea. Marconi described the Needles station as the world's "first permanent wireless station." It was dismantled in June, 1900.

Mass Production of Ships

IN the annual report for last year of the Ship Constructors' and Shipwright's Association Mr. William Westwood, general secretary of the Association, outlined Britain's effort to beat all shipbuilding records, and stated that the building programme would be the nearest thing to mass production that the industry had ever known. Mr. Westwood, who recently took up duties with the Merchant Shipbuilding and Repairs Department of the Admiralty, said that a race would really begin in a few weeks' time and that in shipyards all over the country cargo ships would be taking shape on the stocks faster than our vessels could be sunk. Each yard would build one type of ship only, and that type would be the one it could build fastest and most economically. The ships would be called "emergency" vessels, but although labour would be cut down to the minimum, they would be built to last. They would not suffer the fate of the standard ships of the last war, many of which had to be scrapped. The vessels which had been under construction during the past few months, the report continues, would soon be added to the launching output, and before 1940 was far advanced there would be an exceptionally heavy demand on the fitting-out basins. It could be assumed that some of the vessels under construction would have only a short spell in the fitting-out basins, as quite a large percentage of the work was now completed before launching. The Government's decision to order a large tonnage of tramp vessels of simple type was, of course, the backbone of the yards' activity, and those orders would enable the yards to build economically.

The Mechanism of Magnetisation

By T. F. WALL, D.Sc.*

No. IV

(*Continued from page 320, April 5th*)

IN a previous article[32] an account was given of the effect on the magnetic permeability of pure nickel wire due to coating the wire with a thin film of copper and then heat treating it at a temperature higher than the melting point of copper. It was there shown that for such copper-coated wires the maximum value of the permeability was very much higher than that for nickel wire of the same diameter and heat treated in the same way, but without the coating of copper. It was also shown that the maximum permeability of a heat-treated nickel wire, whether copper-coated or not, was very largely dependent upon the magnitude of the diameter of the wire—that is to say, on the cross-sectional area.

The results of some preliminary experiments on Armco iron wire were also recorded in the previous article and showed in a general way that similar characteristic magnetic features were obtainable for iron wire as for nickel wire. In what follows, the results of a systematic series of experiments carried out with Armco iron wires are recorded, the general features of the experimental technique adopted being the same as has been described in the previous article.

The solenoid used for these tests was about 4ft. 8in. long, and was erected in a vertical position so that the wire under test could be easily suspended co-axially with the solenoid and in the central portion of the core—that is, in the region of uniform magnetic field intensity. Tests showed that the intensity of the magnetic force due to the D.C. excitation of the solenoid was quite uniform over a length of about 30in. at the central portion of the core.

In order to eliminate the effect of the vertical component of the earth's magnetic field, a separate winding was arranged over the excitation winding of the solenoid and supplied from a battery of sufficiently high voltage as to practically suppress any changes of this compensating current which might arise from mutual induction effects when the exciting current was reversed. Actual measurements showed that a current of 0·18 ampere in the compensating winding was required to neutralise the vertical component of the earth's field.

The intensity H of the magnetic field at the central portion of the solenoid was found to be related to the exciting current I amperes by the expression

$$H = 24 \cdot 3 \times I \text{ oersted.}$$

§ 12. *The Effect of Surface Treatment on the Magnetic Quality of Armco Iron Wire.*—It was pointed out in the previous article[33], that, owing to the unsymmetry of the molecular forces at and near the surface of a wire it was to be expected that some inhomogeneity of the material would exist, however carefully the heat treatment was carried out. That is to say, the material at the surface must be expected to be in a condition which is physically different from that of the material at and near the axis of the wire. In consequence of this inhomogeneity it is to be expected that the magnetic quality of the material near the surface of the wire would be different from the magnetic quality near the axis. For this reason, it was argued, any treatment of the surface of the wire which would tend to eliminate the dissymmetry of the molecular forces at and near the surface would correspondingly alter the magnetic quality of the wire as a whole. Any such effect of surface treatment should obviously be more evident in wires of small diameter than for wires of large diameter.

In the first series of tests the effects of several types of surface coating were tentatively examined and it was decided to examine systematically the effect of a coating obtained as follows :—Adjustments to the furnace in which the wire was heat-treated were made so that a sufficient amount of oxygen was allowed to enter and combine with the stream of hydrogen to form water vapour. In this way the iron wire became coated with a bluish-black film of iron oxide, presumably the magnetic oxide of iron, since one known method for preparing such an oxide is to heat iron in steam at a suitable temperature.

Tests were made on a series of wires each 12in. long and of respective diameters 0·010in., $^1/_{64}$in., 0·020in., $^1/_{32}$in., $^3/_{64}$in., $^1/_{16}$in., $^5/_{64}$in. The furnace was maintained at a temperature of about 1320 deg. Cent. and the heat treatment was performed in stages as follows :—After heating to the specified temperature for a definite period of time the furnace was allowed to cool down very slowly; that is, a period of about five hours was necessary to reach the room temperature. The null magnetisation curve was then obtained by means of ballistic tests. The wire was then heated for a further period and allowed to cool down as before, after which another measurement of the magnetisation curve was made, and so on. In this way a graph was obtained relating the values of μ_{max} (see Part I, § 3, Fig. 7) and the time of heating. This graph showed a maximum value after a certain time and in what follows this peak value of the graph will be termed the absolute maximum permeability and will be denoted by the symbol $(\mu_{max})_{abs}$. The time of heating necessary to reach the peak value of the graph was greater for wires of large diameter than for wires of small diameter.

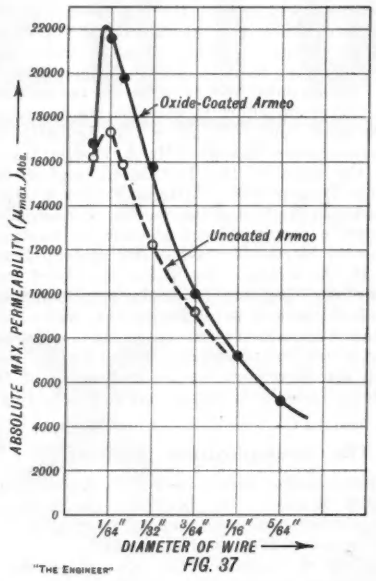


FIG. 37

The absolute maximum permeability $(\mu_{max})_{abs}$ is taken to define the characteristic magnetic quality of the wire for the purposes of these investigations. For this condition the initial permeability μ_o, the quantity $\left.\frac{dB}{dH}\right]_{max}$, the hysteresis loop, the remanent induction B_{rem}, and the coercive force H_c have been recorded in the curves which are now to be discussed.[34] In each case the curves are drawn with the diameter of the wires as abscissæ.

A second series of tests was then carried out for samples of Armco iron wires from the same consignment as those used for the first series. In the tests of the second series, however, the full purification system for the hydrogen stream through the furnace was put into operation, as has already been described in the previous article.[35] Under these conditions the wires came out from the furnace after each heat treatment with the surface of a brilliant silvery appearance.

The procedure for obtaining the values of the characteristic magnetic quantity $(\mu_{max})_{abs}$ was carried out as has been explained already with reference to the first series of tests.

In Fig. 37 are shown the curves for the values of $(\mu_{max})_{abs}$ for the two series of tests. The oxide-coated curves are shown by the full-line curve, and for the uncoated wires by the broken-line curve. It will be seen that for the oxide-coated series of values the curve reaches a peak value of just over 22,000, the corresponding diameter of wire being slightly less than $^1/_{64}$in. (0·396 mm.). For wires of larger diameter the curve falls at first very rapidly, and then more slowly, so that for a wire of diameter $^5/_{64}$in. the value of $(\mu_{max})_{abs}$ is only about 5000. The curve also falls rapidly for values of the diameter which are less than $^1/_{64}$in. This may be accounted for by reason of the fact that the surface skin of iron oxide then begins to form an appreciable percentage of the cross-sectional area, and since the oxide is of relatively low magnetic permeability the aggregate value of the permeability of the wire becomes correspondingly reduced.

For the uncoated wires the broken-line curve in Fig. 37 reaches a peak value of about 17,500 for a wire of diameter of about $^1/_{64}$in. For smaller diameters the curve falls rapidly and then gradually tends towards coincidence with the full-line curve for the oxide-coated wires. For wires of diameter less than $^1/_{64}$in. the curve tends to fall less rapidly than in the case of the oxide-coated wires. The fall of permeability in this case of the uncoated wires may be accounted for by the assumption that the surface skin is magnetically harder than the material near the axis of the wire, this being due to the inhomogeniety caused by the unsymmetrical molecular forces at and near the surface skin of the wire.

In Fig. 38 are shown the values of the initial permeability μ_o (see Part I, § 3, Fig. 7) for the oxide-coated wires and the uncoated wires respectively. It will be observed that the curve for the oxide-coated wires reaches the remarkably high peak value of about 7200, whilst the peak value of the curve for the uncoated wires is only about 4500.

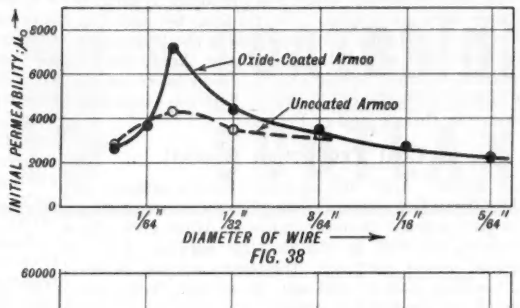


FIG. 38

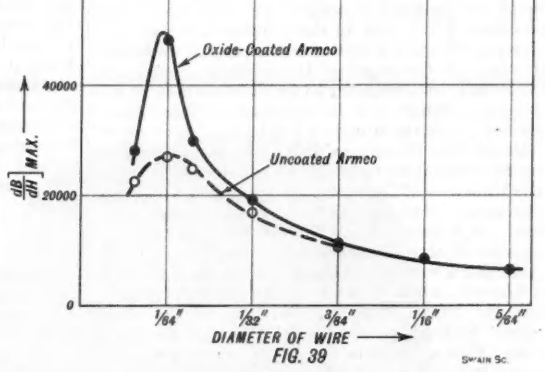


FIG. 39

It is of interest to consider here the theoretical expression (25) given in Part II, § 10, for the maximum possible value of the initial susceptibility κ_o, viz.,

$$\kappa_o = \frac{2}{9}\frac{1}{E}\left(\frac{J_s}{\lambda_s}\right)^2.$$

As already stated, Kersten deduced this expression for the condition that the internal stress $\lambda_s\sigma_i$ is greater than the crystal constant K. The value which is to be assigned for the magnetostriction constant λ_s in the case of anisotropic material, such as iron, is uncertain. The value of this constant, as measured for a single crystal in the crystal direction (100)[36] is $\lambda_s = 20 \times 10^{-6}$ so that, taking Young's modulus to be $E = 2 \cdot 06 \times 10^{12}$ dynes per square centimetre,[37] and the saturation intensity $J_s = 1720$, the foregoing expression gives $\kappa_o = 800$, that is, the theoretically maximum possible value of the initial permeability is $\mu_o = 1 + 4\pi\kappa_o = 10{,}000$.

Fig. 39 shows the values of the maximum slope of the null magnetisation curves—that is, the values of $\left.\frac{dB}{dH}\right]_{max}$ (see also Part I, § 3, Fig. 7)—for the oxide-coated wires and the uncoated wires

* Department of Electrical Engineering, Sheffield University.

[32] THE ENGINEER, June 17th and 24th, 1938.

[33] THE ENGINEER, *loc. cit.*

[34] For the definitions of these respective quantities, see Part I, § 3.

[35] THE ENGINEER, June 17th, 1938, Fig. 1.

[36] *E.T.Z., loc. cit.*

[37] THE ENGINEER, *loc. cit.*, Fig. 22.

respectively. It will be seen that the curve for the oxide-coated wires reaches the high peak value of 50,000, whilst the peak value of the curve for the uncoated wires is 28,000. For the wires of larger diameters the two curves tend to coincide.

Fig. 40 shows the hysteresis loops for the wires

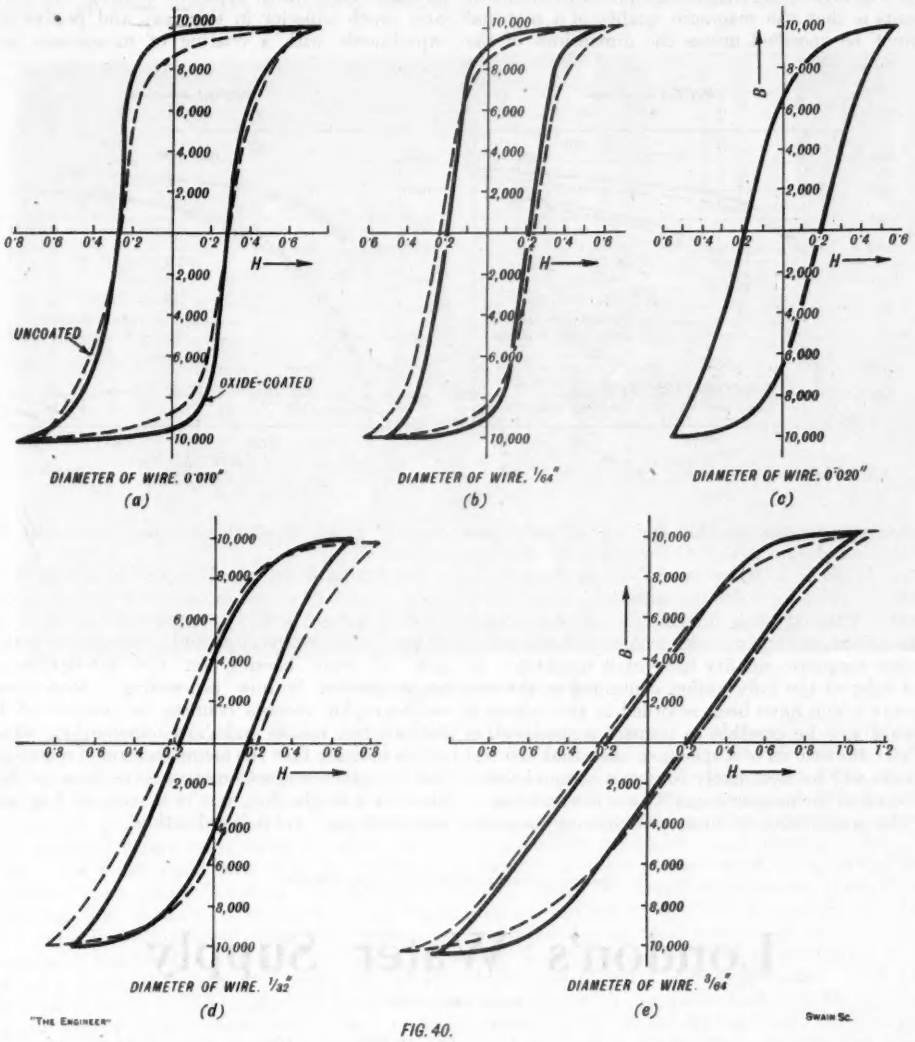
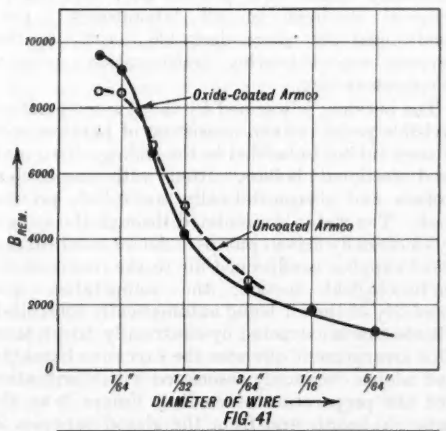
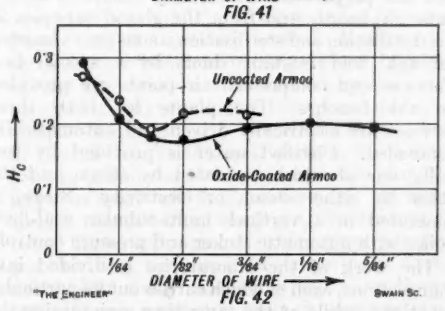


FIG. 40.

of diameters 0·010in., 1/64in., 0·020in., 1/32in., and 3/64in., respectively, the full-line loops referring to the oxide-coated wires and the broken-line loops referring to the uncoated wires. The peak





value of the induction density for all the loops was 10,000 gauss. It is of particular interest to note that the hysteresis loop in Fig. 40 *a* for the 0·010in. oxide-coated wire approximates in shape to the loop given in Fig. 34 for the stressed nickel wire in which the electro-magnetic energy absorbed in performing the hysteresis cycle is wholly irrecoverable and the reversal of magnetisation takes place by means of a single Barkhausen jump of magnitude $2J_s$.

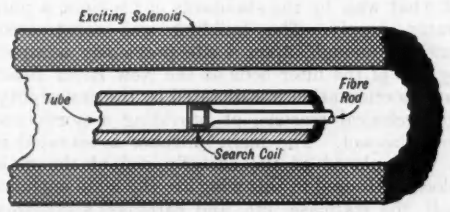
Fig. 41 shows the remanent induction $B_{rem.}$ for the oxide-coated wires and the uncoated wires respectively, and Fig. 42 gives the corresponding values for the coercive force H_c.

§ 13. *Experiments on the Magnetic Penetration in Steel Tubes.*—In the first place some results will be considered[38] which have been obtained from tests on a solid-drawn charcoal-iron tube 48in. long, ¾in. outside diameter, and ⅝in. inside diameter.

The approximate analysis of the iron was as follows :—

	Per cent.
Carbon	0·033
Manganese	0·130
Silicon	0·180
Phosphorus	0·007
Sulphur	0·017

For these tests a search coil of 1420 turns

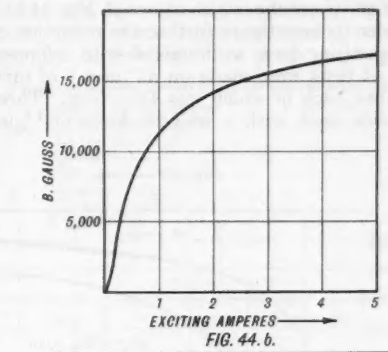


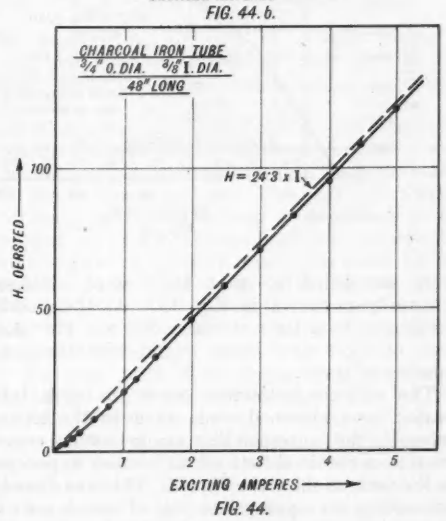
was wound on a fibre rod so that it could be inserted and fixed at the central portion of the iron tube, as is indicated in Fig. 43. The iron tube was then arranged in the magnetising solenoid and the value of the magnetic flux which was enbraced by the search coil was measured for a series of exciting currents from 0 to 5 amperes. The mean density of this flux, as obtained by dividing the magnitude of the flux by the mean area of the search coil, then gave the mean value of the magnetic force H inside the tube.

The results of this test are shown in Fig. 44.

[38] See also *Nature*, Vol. 142, December 10th, 1938.

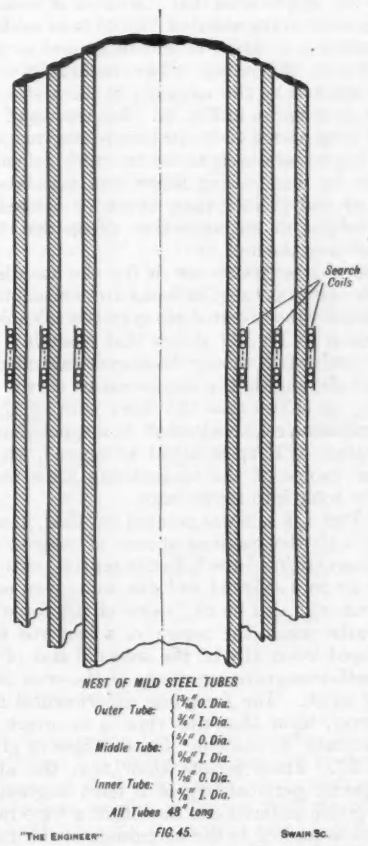
The broken line gives the relationship $H=24\cdot3\times I$ —that is, the intensity of the force in the solenoid core when the tube is removed, whilst the full-line curve shows the way in which the magnitude





of this force is modified by the presence of the tube.

In Fig. 44 *a* is shown the reduction of the magnetic force due to the presence of the tube


Search Coils
NEST OF MILD STEEL TUBES
Outer Tube: 15/16" O. Dia. ⅞" I. Dia.
Middle Tube: ⅝" O. Dia. 9/16" I. Dia.
Inner Tube: 1/16" O. Dia. ⅜" I. Dia.
All Tubes 48" Long
"THE ENGINEER"
FIG. 45.
SWAIN SC.

—that is, for any given value of the exciting current the intercept Δ H on the corresponding ordinate in Fig. 44 has been plotted. The interesting feature of this result is that the maximum effect of the tube in reducing the magnitude of the force

is obtained in this particular case for an exciting current of about 1·25 amperes, whilst this diminution ΔH becomes progressively smaller as the exciting current is increased.[39]

For reference purposes, the null magnetisation curve of the iron tube is also shown in Fig. 44 *b*.

In order to investigate further the reduction of the magnetising force as described with reference to Fig. 44 tests were made on a "nest" of mild steel tubes, each of which was 48in. long. Three such tubes, each with a wall thickness of $^1/_{32}$in. were assembled so that they were arranged co-axially as shown in Fig. 45. At the middle portion of each tube a search coil was provided, each of these coils being wound with the same number of turns.

The null magnetisation curve for each tube having been obtained when alone in the testing solenoid, the corresponding magnetisation curves were then obtained for each tube when in position in the nest, as shown in Fig. 45. This was done by connecting the appropriate pair of search coils in opposition. For example, the search coil on the outer tube and that on the middle tube when connected in opposition gave the magnetisation curve for the outer tube and so on. In all the tests due allowance was made for the flux in the air space as embraced by the search coil in question.

The results of these tests are shown in Figs. 46, 47, and 48, respectively. In each of these figures the full-line curve shows the magnetisation curve for the tube when arranged alone in the solenoid and the broken-line curve refers to the magnetisation curve when the tube was assembled in the nest. It will be seen that the effect of assembling in the nest arrangement of Fig. 45 is to modify the magnetisation curves of the tubes and each tube is affected differently. The outermost tube is least affected by the assembly in the nest arrangement, as is shown in Fig. 46. For a range of values of H from about 40 to 70 oersted the magnetisation curves are seen to be in exact coincidence, whilst for magnetising forces less than about 40 oersted and greater than about 70 oersted there is a slight de-magnetisation effect due to the assembly in the nest.

The magnetisation curve for the middle tube of the nest is notably different from that obtained when the tube is tested alone in the solenoid, and reference to Fig. 47 shows that assembly in the nest produces a strong de-magnetising effect over the whole range of the magnetisation curve.

Fig. 48 shows that the inner tube of the nest experiences a relatively small de-magnetising effect for values of H up to about 40 oersted, whilst for larger values of the magnetising force the two curves come into coincidence.

In Part I, § 1, it was pointed out that, in accordance with the classical theory of magnetisation, the magnetising force H in the central portion of a long air core solenoid and due to a given exciting current will also be the value of the force which will exist inside the centre of a long rod or wire arranged co-axially in the solenoid and of which the self-demagnetising effects of the ends is negligibly small. The foregoing experimental results, however, show that this view is incorrect and is inadequate to account for the results given in Fig. 37. These results show that the absolute maximum permeability of a ferro-magnetic wire of a given material can lie within a wide range of values according to the magnitude of the diameter of the wire.

As already pointed out elsewhere,[40] however, the results can be accounted for if it be assumed that magnetisation is initiated at the surface and proceeds inwards so that the induction density B will vary from place to place in a cross section of the wire, the magnitude of B at any point being dependent upon the radial depth of that point.

It has already been pointed out that the results which have been recorded in the earlier portions of Part III of this article show that one aspect of the classical theory of the mechanism of magnetisation is incorrect. A further consequence of these test results is that the magnetic quality of a material cannot be specified unless the dimensions of the test sample are also specified and a practical aspect of this conclusion is that the dimensions of a test piece should be included in any specification of the test requirements which the material is expected to fulfil. Without such information of test sample dimensions, tests on samples which are intended to define magnetic quality have little meaning. In the light of the information contained in the test results which have been recorded in this article it should now be possible to prepare a specification of the dimensions of a specimen such that the test results will be most likely to give a comprehensive account of the magnetic qualities of the material.

The possibilities of notably improving magnetic quality by the relatively cheap and simple method of suitable surface treatment appear likely to be of considerable practical significance. The results already obtained for the case of a surface coating of a suitable oxide of iron have shown the kind of improvement which may be expected. It is not, however, to be supposed that this type of coating exhausts these possibilities. It is, in fact, very probable that other types of coating will prove very much superior in this way and preliminary experiments with a coating of manganese have already given most encouraging results in this direction.

The full implications of the results as regards the value of the magnetic intensity in the neighbourhood of the surface of a magnetised material are, as yet, by no means clear and a detailed investigation of their bearing on the mechanism of magnetisation is now proceeding. Preliminary oscillographic records confirm the nature of the ballistic test results and show some curious effects which indicate that the magnetisation of a material due to a given magneto-motive force does not take place in a single step, but in a more or less well-defined sequence of delayed action.

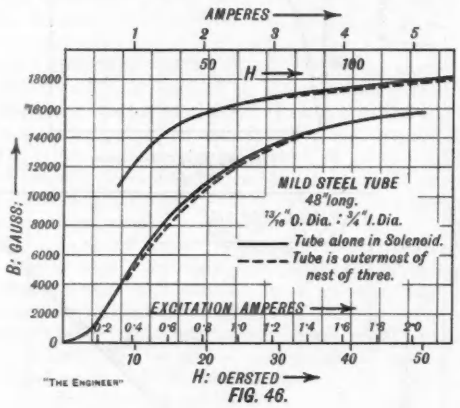


FIG. 46.

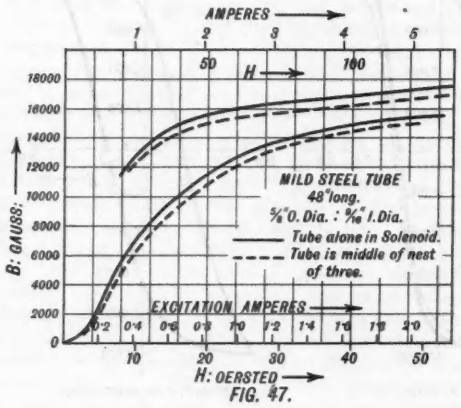


FIG. 47.

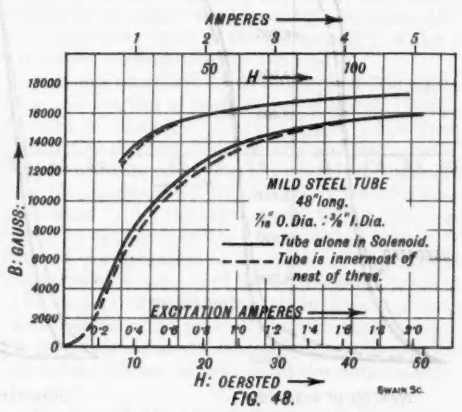


FIG. 48.

[39] See also *Nature*, Vol. 143, February 25th, 1939.

[40] *Nature*, Vol. 141, page 1039, 1938; Vol. 142, page 875,1939.

London's Water Supply*

The New Laboratories

THE year 1938 marks an epoch in the annals of the Metropolitan Water Board and in particular of the Water Examination Department, for on October 17th, 1938, the new laboratories were formally opened by the Minister of Health, the Right Hon. Walter Elliot, M.C., M.P.

After careful consideration, it was decided that the new laboratories should be situated in the confines of the central offices of the Board at New River Head, Rosebery Avenue, in the borough of Finsbury. The situation is appropriate, since here it was that Hugh Myddelton, citizen and goldsmith of London, first brought "the sweet waters of Hertfordshire" from Chadwell Spring and Amwell to the City of London in 1613, thus conferring upon the city the inestimable benefit of what was, by the standards of his time, a pure water supply. The building was constructed, suitably enough, upon a site previously occupied by one of the filter beds at the New River Head, and its orientation was dictated by the desirability, for technical reasons, of providing a north and south aspect. The main entrance is situated in a wing placed at the easterly end of the main block. Housed in this wing are the main entrance hall, the staircase, lift, and caretaker's quarters. In the main part of the building the accommodation is arranged to the north and south of central corridors in the lower three floors, while on the second floor rooms are provided on the north side only. This arrangement will permit of further accommodation being provided on the south side of this floor should it be required in the future. The accommodation has been so arranged that all laboratories have a northerly aspect.

In order to avoid the necessity for installing any service after the completion of the building, which would involve the opening up of the fabric, it was considered desirable to provide for all services which are known to be of use. Of these the following, which in some cases are original in their conception, may be mentioned:—Tap water from two separate supplies; softened water for condensers and washing up; hot water system; compressed air lines; vacuum lines; high pressure steam; low pressure steam; distilled water; electricity (light and power, A.C. and D.C.); artificial daylight in all laboratories; gas; conditioned air where desirable; anti-vibration devices; central heating; refrigeration; internal telephone system.

The building is warmed by the low temperature invisible panel system, consisting of jointless coils of steel tubing imbedded in the ceiling. Two coal-fired sectional boilers, fitted with mechanical stokers and thermostatically controlled, provide heat. The water is circulated through the system by electrically driven pumps. An air-conditioning plant supplies conditioned air to the rooms of the bacteriological section, the temperature and humidity of the air being automatically controlled. Vitiated air is extracted by electrically driven fans. This arrangement obviates the excessive humidity and odours commonly associated with sterilisation and the preparation of media. Fumes from the fume cupboards and from the glazed canopies in the distillation and sterilisation rooms are exhausted through acid-resistant ducts by a special fan. Vacuum and compressed air points are provided on the benches. The plants for both these services are electrically driven and automatically controlled. Distilled water is provided by two stills, one of which is heated by steam and the other by either steam or electricity. Steam is generated in a vertical multi-tubular coal-fired boiler with automatic stoker and pressure control.

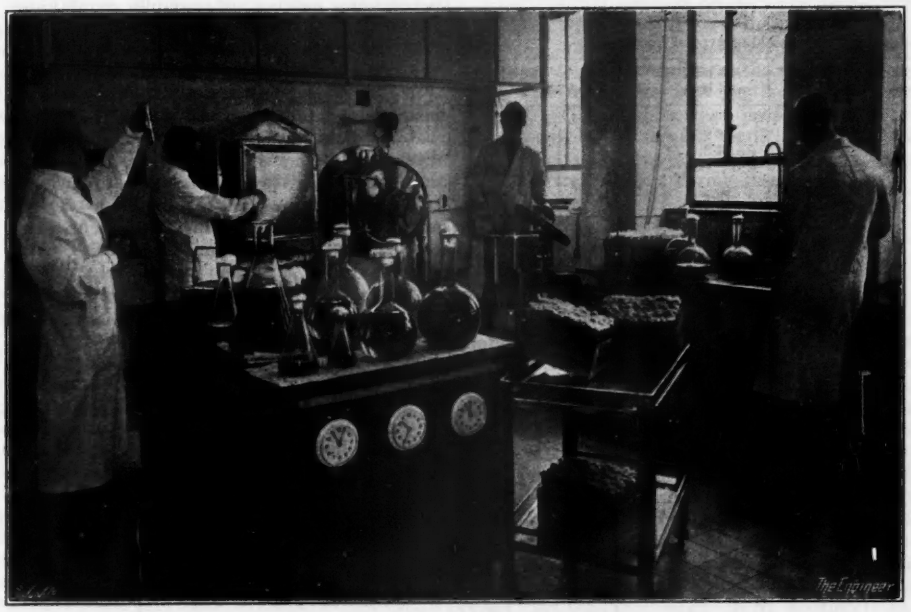
The work of the laboratories is divided into four sections, each of which carries out its particular functions, while at the same time maintaining the closest liaison with the others. The sections are:—Administrative, including general administration, clerical, organisation for the collection of samples and statistical recording; chemical; bacteriological; and biological.

* Excerpts from the Annual Report of the Metropolitan Water Board for the year ending December 31st, 1938.

The chemical section is housed on the top floor. The distillation plant, balances, still, and fume cupboard are situated each in a room specifically designed for the purpose to which it is put. The bacteriological section on the first floor has been so designed that successive operations are performed throughout a series of nine communicating rooms commencing with the washing up room and ending with the sub-culture room. The washing up room contains a range of stainless steel sinks fitted with wash baths for acid and supplied with distilled water. A special slop sink and autoclave are provided for dealing with contaminated media, and a destructor for contaminated plugs is situated in the basement. The cleansed glassware is dried in heated drying cupboards which open also into the media preparation room, thus obviating the necessity of carrying the clean glass from room to room. The autoclave is loaded from the preparation room and unloaded in the sterilising room, thus reducing again the amount of traffic in the preparation of media. The preparation and sterilising rooms are of aseptic construction and contain sterilisers designed to the specification of the Board, to which heat is supplied by live steam and electricity. All apparatus is of special anti-corrosive metal with mirror finish. The receptacles, having received their quota of media and having been plugged and sterilised, pass on to the media stock room where they are stored until required in the general laboratory.

Sets of media appropriate to the samples which it is anticipated will be received on any particular day are laid out in the general laboratory. The routine samples are taken in the morning and are transported to the laboratory in iced sample boxes by a fleet of motor vans. The samples, on arrival, are conveyed to the general laboratory where each is connected up with its appropriate range of media, and where the serial number which was allotted to it when drawn is transcribed on the media containers. The sample is registered under this serial number, which is used for its identification in all subsequent tests. The samples having been put up are trolleyed into controlled temperature rooms which operate at 22 deg. Cent., 37 deg. Cent., 42 deg. Cent., and 44 deg. Cent. These rooms take the place of box incubators, and are a great convenience in handling a large number of samples. They exhibit certain original features. The necessary air temperature is provided by electric radiant heat from the walls, and this sytem, assisted by electric fans, eliminates hot spots and areas of unequal temperature. The thermostatic control in the 22 deg. Cent. room permits of cooling or heating of the room as necessary. In view of the large amount of fluid undergoing incubation, special ventilation is employed, the incoming air being drawn through renewable glass silk filters, and by the operation of adjustable dampers suitable humidity is maintained. The temperature of each incubator room is thermostatically controlled and recorded. After incubation, tubes are sorted in the adjacent sorting room and positive tubes pass on to the sub-culture room for further investigation. A dark counting room for the performance of special counts adjoins the sorting room. Three additional rooms provide accommodation for bacteriological assistants, while the laboratory of the senior bacteriological assistant and two research laboratories are situated on the ground floor.

The main part of the biological section is situated on the ground floor and consists of a biological laboratory, a biochemical laboratory, a micro-photographic room fitted with special anti-vibration devices and a photographic dark room. In the basement is provided a somewhat original unit consisting of a refrigerator room, a cool room for the temporary storage of samples and a laboratory which can be maintained at a suitable temperature for special algal investigations. The cooling of these is performed by a refrigerating plant which also provides ice for use in the laboratories. Adjoining the cool laboratory is a room equipped for the performance of more extensive and less cleanly biological experiments, a biological wash and a photograph store. The basement also provides accommodation for samplers, consisting of office, drying room for samplers' clothing, and a wash room for chemical sample bottles fitted with movable racks, Monel metal drain, and pedal taps operating upward and downward jets of warmed water. The remainder of the basement furnishes accommodation for the machinery operating the services, the ozone apparatus, stores, and domestic offices.



MEDIA STERILIZATION ROOM

THE WORK OF THE LABORATORIES

During the year under review, the total output from the Board's works was 111,438 million gallons, an average of 317·61 million gallons per day. This constitutes a daily increase of nearly 7 million gallons over the high record established in 1937.

Details of the supply are tabulated below :—

Supply	1937			1938		
	Percentage of first class samples (Neg. 100 ml. *Bact. coli*).	Output in million gallons		Percentage of first class samples (Neg. 100 ml. *Bact. coli*)	Output in million gallons	
		Daily average	per cent. of total daily average		Daily average	per cent. of total daily average
Thames-derived waters	99·6	195·37	62·7	98·7	207·21	65·2
Lee-derived waters (including Ferry Lane)	99·3	44·62	14·5	99·1	39·37	12·4
New River-derived waters	98·8	34·95	11·2	97·4	34·39	10·8
Northern District Wells (unfiltered)	96·9	7·39	2·3	97·0	7·88	2·5
Kent Wells (unfiltered)	98·4	28·46	9·3	99·1	28·76	9·1
Terminally chlorinated waters	99·4	276·42	89·1	98·6	293·28	92·3
Well waters not chlorinated	97·7	34·37	10·9	98·5	24·33	7·7
Total output from works	99·0	310·79	—	98·5	317·61	—

The average daily supply of consumers for 1938 was 312·77 mg.

More precise laboratory control comes as a corollary to the higher rates of filtration which are necessitated by increased output by the works, and this demand is reflected in the number of samples examined, as shown in the following table.

The number of samples examined (see table below), if compared with the previous year, shows an increase of 11,493, and this has thrown a heavy demand upon the staff of the laboratory, a demand increased by the temporary disorganisation which inevitably resulted from the move from Nottingham Place to the new laboratories. Bacteriological samples were examined as a daily routine from the Rivers Thames and Lee, and the New River; from prechlorinated waters; from primary filtrates; from general filter wells, from the Kent and Northern District Wells, and from each main conveying water into supply. Individual filter beds were examined in rotation, the drawing of samples being so arranged that the filtrate of each working bed came under test about once a week. All storage reservoirs in use were examined weekly. In addition to the examination of the above-mentioned routine samples, many bacteriological tests were made for research purposes and in the performance of special investigations. The year was marked by the introduction of two modifications in the routine test for coliform organisms, namely, the substitution of brilliant green bile broth for the indole test as rapid confirmation of the 10 ml. MacConkey broth tube in the presumptive test, and the introduction of a citrate tube in the confirmatory test.

Number of samples examined for various purposes during 1938.

Routine bacteriological	27,970
Special bacteriological	984
Routine chemical	4747
Special chemical	437
Taste	11,362
Deposits	1942
Micro-photographs	803
Filterability	2170
	50,415

Media Preparation

Total number of tubes for the year ...	428,061
Maximum number prepared in any one month, October	47,369

The main work of the chemical section consists of the routine examination of samples of raw, stored, filtered, and well waters and special examinations of samples drawn, either as a result of "complaints," or for the elucidation of special problems. The majority of these analyses are of a sanitary nature and consist of the estimation of the free and the albuminoid ammonias, chlorides, nitrates, nitrites, oxygen absorbed from acid permanganate, hardnesses, and *p*H values. Another aspect of the work of the chemical section, and one which is rapidly extending, is concerned with special analyses of waters performed with a view to elucidating chemical problems in connection with the growth and control of algae in reservoirs.

The recently formed biological section has, during the last few years, paid considerable attention to the possibility of forecasting the duration of algal growths in reservoirs. Such forecasts, it is hoped, will be of use in two ways. In cases where the available information points to the relatively speedy termination of a particular algal outbreak, the safer course may be to undertake no special treatment, such as the application of copper sulphate or alum. Where, however, there is reason to believe that the trouble will be prolonged, treatment is indicated and advice to this end may be offered.

With the appointment of additional assistance to the biological section, it has been possible to begin a study of the flora growing on the sand surface of some 119 secondary and slow sand filters. This is a task of considerably practical value. It has long been realised that filtration must be impeded by a local growth of algae on sand filters, but practically nothing is known about the types of algae responsible, about their seasonal distribution, or the influence of depth of water and light intensity upon their rate of growth. A start has been made on what it will be realised is a large problem. Samples from the "skins" from 119 filter beds are examined as and when these selected beds are emptied for cleaning. The work will be continued during 1939, and it is hoped to

arrive at an estimate of the part played by local growths in impeding filtration.

Works Efficiency

Chlorination.—The ammonia chlorine treatment of prefiltration waters, in the Staines and East London aqueducts and in the New River, has been continued throughout the year.

The bacteriological results of this treatment are shown in the following table :—

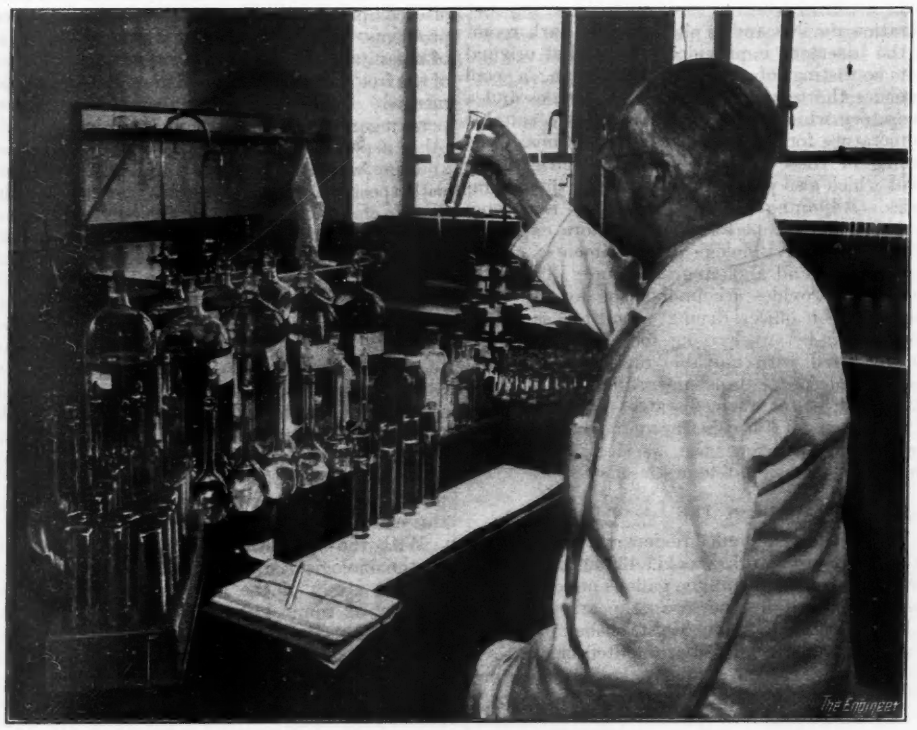
Supply	Colony count per ml.	*Bact. coli* Test (Percentage of samples yielding typical *Bact. coli*.) Neg. 100 ml.	+100 ml. and less	+10 ml. and less	+1 ml. and less	+0·1 ml. and less	+0·01 ml. and less
Staines Aqueduct—							
before treatment	49	3·3	96·6	71·6	38·2	13·3	—
after treatment ...	22	55·7	44·2	26·1	7·2	0·8	—
Lee Aqueduct—							
before treatment	29	13·8	86·2	49·6	12·2	2·4	—
after treatment	20	78·1	21·8	3·6	0·4	—	—
New River—							
before treatment	91	0	99·9	93·8	49·3	12·9	0·4
after treatment	25	93·5	6·4	1·6	—	—	—

In all these cases, treatment is given to water in open channels which pass through populated areas and the possibilities of repollution from adventitious sources, such as drainage from the banks, and bird life, are always present.

A comparative study of the bacteriological results obtained from works receiving pre-chlorinated water and those whose supplies are not so treated shows a decided improvement on the basis of the yearly average, and the figures furnish indisputable evidence of the value of pre-chlorination. Nevertheless, if the monthly averages are studied, it is seen that the improvement which results from pre-chlorination is very much greater during the winter months than during the summer.

The lessened value of pre-chlorination during the warmer months is not merely comparative but is also absolute in that, despite a raw water of greater purity, the produce resulting from pre-chlorinating is of poorer bacteriological quality in summer than in winter. In summer, moreover, the biological activity on the filter beds is greater and this, on the whole, enhances their efficiency. The opposite result might therefore justifiably be expected. This somewhat intangible falling off in efficacy in summer is difficult to illustrate, but can be observed throughout records extending over a number of years. The causes of these phenomena are not readily determined, since a number of variable factors are involved.

Terminal ammonia chlorine treatment of all river-derived supplies was continued, and a figure of 98·6 per cent. of first class samples of water passing into the mains was obtained. This is slightly less than that obtained in 1937, but 1938 will be remembered as a difficult year, particularly in December, when, during severe frosts, the consumption of water reached unprecendented heights and the low temperature seriously interfered with the administration of the sterilising reagents. Some of the wells which are pumped directly into supply showed signs of deterioration and were immediately dealt with by exclusion from supply until chlorination apparatus had been installed. In the Kent District, chlorine and ammonia gas apparatus was installed at Crayford No. 3 Well and at Plumstead, while at Crayford No. 1 Well, which is only used as a stand-by plant, tanks for the administration of ammonium sulphate and hypochlorite were fitted. In the Northern District, ammonia and chlorine gas plants were installed at Alma Road and Waltham Abbey Wells and sulphate of ammonia and hypochlorite tanks at Rammey Marsh. East Ham, Old Ford, Wanstead, and Park Wells also demanded treatment, but as they each contain sufficient natural ammonia, chlorine alone was deemed to be adequate. In view of the fact that Rye Common Well gave evidence of heavy pollution, a further barrier was effected by chlorinating the water before filtration in addition to the existing terminal treatment.



A CHEMICAL LABORATORY

Filtration.—The average daily output from all the works was 317·61 million gallons of which 280·97 million gallons were river-derived supplies. This steady increase in the quantity of water supplied during recent years is noteworthy. In 1935 the corresponding figures were 280·7 and 248·0 ; thus the output of filtered water has increased by 13·3 per cent. in three years.

Owing to the necessity of utilising some of the land occupied by filter beds at Hampton in connection with the remodelling of these works, the available area for filtration has decreased from 175·64 acres in 1935 to 169·1 acres in 1938, and this fact should be taken into account in assessing the increased load on the filters. Expressed in terms of million gallons filtered per day per available acre, the figures for the years 1935 and 1938 are 1·41 and 1·66 respectively, an increase in three years of 17·7 per cent. It is not surprising that these facts are reflected in the degree of bacteriological purification effected by the filters.

The raw Thames gave slightly worse average results in 1935 than in 1938, the colony counts were almost identical (374 and 375), but in the former year 93·8 per cent. of the samples contained *Bact. coli* in 1 ml., while in the latter only 82·2 per cent were similarly polluted. The picture is reversed when one looks at the results for filtered Thames water. The colony count has risen from 3·4 per ml. in 1935, to 9·7 in 1938, and the percentage number of samples containing no *Bact coli* in 100 ml. has dropped from 72·0 per cent. to 68·2 per cent. Subsequent ammonia chlorine treatment has raised this figure to 98·7.

Wells.—It is perhaps not fully appreciated that nearly a million consumers are supplied with well water which only a few years ago was pumped direct from the wells into the mains without any purification process, a procedure which was fully justified by the results of bacteriological and chemical examinations. In recent years the attention of those responsible for the purity of water supplies has been particularly directed to the standards of purity required for a well supply with a consequent tightening up of these standards. The whole subject was carefully reviewed by the Board in the early part of the year, and the principle of sterilisation of all well supplies was adopted. This policy is gradually being brought into effect, but until experiments are completed as to the most efficient means of sterilisation, only those wells which do not give uniformly coli-free results are being treated.

As stated in the previous report, the frequency of sampling has been largely increased, and a mass of data is now available upon which tentative conclusions may be drawn. During the year, some 34 wells have been regularly examined involving 7402 bacteriological samples. In addition to the usual *Bact. coli* test and the colony count on agar at 37 deg. Cent., counts have been made on agar at 22 deg. Cent. after three days incubation. As might be expected these figures show considerable fluctuations, but an attempt has been made to arrive at a normal working range for each well. This range may be defined as the extremes between which not less than 70 per cent. of the samples fall.

The River Thames as a Source of Potable Water

The bacterial content of the river was highest in January and December, with the best conditions prevailing during the warmer months. A Sonning Bridge sample for June 13th shows an unexpected deterioration in quality which may perhaps have been caused by local rainfall, but no evidence of this has been obtainable. In view of the prevailing tendency to place increasing reliance on bacteriological in preference to chemical analysis, it is of interest to note that this sudden influx of dangerous pollution, which is shown throughout the bacteriological tests, is not indicated in any way in the chemical results.

The general trend of the bacterial flora, as observed in previous years, is maintained. There is some indication of a fall in purity at Sonning Bridge, followed by improvement at Hambledon Lock and Bourne End, with a second deterioration at Ruddle's Pool which is maintained down to the Board's intakes, but this cannot be said to be well defined, nor is it observable in the chemical results. Seasonal changes are, in fact, much more pronounced than are regional, and the degree of pollution closely follows the natural flow of the river as recorded at Teddington Weir.

The effect of the past season's chemical analyses has been to raise slightly most of the averages. The mean results over several years, however, show very little chemical deterioration in the quality of the water during its passage from Tilehurst to Littleton Intake, despite the entry of effluents from numerous sewage works. The albuminoid nitrogen has risen only from 0·0174 to 0·0193, the oxygen absorbed from permanganate from 0·200 to 0·211 and the B.O. figure from 0·148 to 0·204 expressed as parts per 100,000. The chloride content has risen from 1·71 to 2·09. This figure indicates the total sewage pollution received, since, unlike most of the other values, it is not reduced by the natural purifying agencies of the river. The very slight increase in the pollutive indexes, both chemical and bacteriological, in a river receiving sewage effluents at frequent intervals, furnishes a striking example of the powers of self-purification attributable to natural agencies within the river itself. This observation supports the contention, pre-

viously made, that the introduction of sewage effluents in comparatively small quantities at intervals is preferable to their collection into one large outlet. It should, however, be emphasised that the apparent disadvantage of the collection of large quantities of sewage into a single unit may be more than offset by the increased efficiency of treatment and control which may be expected in a large and modern sewage purification works.

The index of impurity suggested by Dr. J. F. Beale is a useful figure for comparing the condition of the Thames at the present time with that in former years. The index is obtained by adding ten times the albuminoid nitrogen to the oxygen absorbed from permanganate in four hours at 80 deg. Fah. and dividing the sum by two. In the Board's laboratories the permanganate test is carried out for three hours, but it has been found that the extra hour gives a figure only 5 per cent. higher, and this allowance has been made in arriving at the index quoted.

Year	Index	Year	Index	Year	Index
1906–07	·1585	1917–18	·1860	1928	·1645
1907–08	·1990	1918–19	·2150	1929	·1825
1908–09	·1535	1919–20	·1580	1930	·1690
1909–10	·2090	1920–21	·1755	1931	·2015
1910–11	·1965	1921–22	·1535	1932	·2025
1911–12	·1855	1922–23	·1800	1933	·1685
1912–13	·1830	1923–24	·1780	1934	·1910
1913–14	·1830	1924–25	·2355	1935	·2135
1914–15	·1770	1925–26	·1925	1936	·2025
1915–16	·2020	1926	·1775	1937	·2298
1916–17	·1730	1927	·2195	1938	·2359

Mean = ·1895

The index for 1938 is 0·2359, which is slightly higher than any other year in the above table.

The filterability of the water is influenced by two factors, either separately or in combination. These are (1) the inorganic silt carried chiefly by flood waters, and (2) the algal content of the water. During January and December, the months in which the highest flows at Teddington Weir were recorded, the filterability figure was reduced to zero by the heavy silt, algal growth being almost entirely absent. February showed marked improvement coincident with a lessened flow except at two stations, Sonning Bridge, where silt for no apparent reason was excessive, and Walton, where silt played a part assisted by a light crop of *Melosira*, *Synedra*, and *Nitzschia*. These growths extended up river to Littleton Intake, though in lesser degree. The April survey demonstrated a gradual increase in silt from Reading down river, with the spring crop of diatoms, chiefly *Stephanodiscus Hantzschii*, intervening from Bells of Ouseley downwards. May showed a general improvement with moderate silt and a light crop of algae. The summer algal maximum is reflected in the poor filterability figures in June, the crop of *S. Hantzchii* being particularly heavy at the lower three stations. This condition persisted in only slightly less degree in July, but had subsided in August. A poor figure recorded for Walton in the latter month was due to heavy silt. It would appear that the heavier silt usual at this station may be attributed to some local disturbance, possibly the unloading of coal barges which takes place a short distance above the sampling point. The improvement noticed in August persisted into October, although silt and a moderate crop of algae again produced a poor figure at Walton. By December, the river had thrown off the algal growths, but the flow at Teddington had again reached a high figure and living suspended matter had been replaced by silt.

It will thus be seen that no sooner does the river overcome one ailment than it is beset by the other, and not infrequently it is subjected in less degree to the baleful influence of both at the same time. When the algal crop in the reservoirs is rising and filtration difficulties are becoming daily more acute, the fact that the raw river water, if passed directly on to the filters, may present equal or even greater obstacles to successful treatment, provides a great measure of consolation. It is, moreover, a further justification of the policy of the board in regarding the provision of large storage reservoirs, not only as an insurance against shortage of supplies during times of drought, but also as an adjunct to the artificial purification processes for which too high a price, in the form of filtration difficulties due to algal growths, has not been paid.

Rainfall and Flow

The total rainfall for the year 1938, taken from the average of 12 stations in the catchment area above Teddington, amounted to 24·80in., which is 3·44in. below the standard average of 28·24in. During the three months February, March, and April, only 1·13in. were recorded, compared with the standard average of 5·91in., but, notwithstanding this fact, the amount for the whole year was not remarkably low, the total in 1921 being 16·52in., and in 1933, 22·65in. The rainfall was normal during the last six months of 1938, but well levels at various points in the catchment area at the end of the year indicated that underground water had not then risen to its normal height.

The total natural flow of the river for the year, measured at Teddington Weir, amounted to 362,575·6 million gallons, which is equivalent to 6·57in. of rainfall run off over the whole catchment area, and represents 26·5 per cent. of the total rainfall. This is a normal proportion for such comparatively low rainfall conditions, the average rainfall having a run-off of 32 per cent. Owing to the extremely low spring rainfall, the rate of discharge at Teddington during the summer months fell considerably, which necessitated the daily abstractions of the Metropolitan Water Board being subjected to a certain measure of restriction, in order to preserve the statutory daily rate of discharge at Teddington. There was only one day in 1938 when the recorded natural flow at Teddington Weir exceeded 4500 m.g., per diem. The average number of such days is eleven. The year was, therefore, not one of excessive flooding. The river was at its lowest in August, the natural flow at Teddington being 259·3 m.g. per diem on the 22nd. The same month also showed the lowest monthly average of 343·2 m.g. per diem. These surveys have now covered periods of drought and excessive rainfall, and the results confirm the belief that, with the threefold purification barrier of storage, filtration, and chlorination, Thames water is eminently suitable as a source of potable water.

H.M.S. "Thetis"*

ABOUT 3 p.m. British Summer Time on June 1st, 1939, the "Thetis" with 103 men on board sank in Liverpool Bay whilst engaged in the operation of a trial dive. The immediate cause of the casualty was the opening of the rear door of No. 5 torpedo tube when the bow cap was open to the sea.

The "Thetis" is a submarine 275ft. long, and is divided into six main compartments :—(1) Torpedo tube compartment; (2) torpedo stowage compartment; (3) mess space; (4) control room; (5) main engine room; (6) steering compartment. There are six torpedo tubes, arranged in two tiers of three each, Nos. 2, 4, and 6 being in the port tier and Nos. 1, 3, and 5 being in the starboard tier. No. 5 tube is about 21in. in diameter. Its mouth is closed by a circular bronze plate called the bow cap. When the bow cap is opened it swings back into a position in which it lies fore and aft with the midships of the vessel, thereby leaving a free path for the torpedo from the tube to the sea.

Each bow cap is opened or shut by telemotor power which is operated by a lever. The bow cap of No. 5 tube is always below the sea level when the ship is afloat.

The after end of the tube is in the torpedo tube compartment. This compartment has a narrow alley way between the starboard tier of tubes and the starboard side of the vessel. There is also a narrow alley way amidships between the two tiers of tubes.

No. 5 tube is the lowest tube of the starboard tier. On the starboard side of the alley way between the tier of tubes and the ship's side there is a panel of levers called the bow cap operating levers. There are three levers, in a vertical line one above the other. By means of telemotor power the top lever operates the bow cap of No. 1 tube, the middle lever operates the bow cap of No. 3 tube, and the lowest lever operates the bow cap of No. 5 tube. The lower end of No. 5 lever is about 5ft. above the floor of the alley way. The lever is about 11in. long.

In order to open the bow cap of No. 5 torpedo tube the lever is pushed forward by hand about 45 deg. from a vertical position. The bow cap at once starts to open, and in six to seven seconds is wide open. Similarly, in order to close the bow cap, the lever is pulled aft about 45 deg. from a vertical position.

Each lever has a pointer attached to its upper end. This pointer moves with the movement of the lever over the face of a dial on which are stamped the words "shut" and "open." About mid-way between the two words there is a vertical line cut in the face of the dial. There is also a vertical line cut on the pointer on the lever. When the line on the pointer is in alignment with the line on the panel the lever is in what is called the "neutral position." When the lever is in neutral position, the power operating on the bow cap, whether to open or to close it, is locked in the system, and continues to exert its pressure, irrespective of what may happen to the main telemotor system.

Experiments were made with No. 5 lever of the "Thetis" after she was raised. These experiments showed that if the lever is placed more than 12 deg. towards the "open" position sufficient oil will pass through the valve to cause the bow cap to creep open, and it will continue to creep open so long as the operating lever remains in that position, until it has become wide open.

On each side of each lever there is a small wheel which admits power to the control valve. By turning these wheels power to open or close the bow cap (subject, of course, to the working of the lever) is introduced to the system. There are also two "isolating" valves, which are used to isolate the telemotor power from the whole of the tube compartment. These valves are situated in the compartment immediately abaft the tube compartment.

At the forward end of the alley way between the two tiers of torpedo tubes there are six mechanical indicators one above the other, which are connected to the six rams which actually open or shut the bow caps. No. 5 mechanical indicator is the lowest of the six; its lower edge is about 9in. above the floor. Immediately above it is the indicator for No. 6 tube. Each mechanical indicator consists of a dial and a pointer. The dial has the words "shut" and "open" stamped on it. In the case of No. 5 mechanical indicator the word "shut" is at 5 o'clock on the dial and the word "open" is at 7 o'clock on the dial. In the case of No. 6 indicator the word "shut" is at 11 o'clock on its dial and the word "open" is at 2 o'clock. In other words, in the case of No. 5 tube the pointer would be to the right of a vertical line on the dial when the bow cap is shut, and in the case of No. 6 tube the indicator would be to the right of a vertical on the dial when the bow cap is open.

The dial of No. 5 tube mechanical indicator is difficult to see because there is a horizontal bar immediately abaft the dial. This bar obstructs a view of the dial unless one goes right forward and, bending down, looks down over the bar. The pointer of each indicator starts to move when the bow cap starts to move. Assuming that No. 5 bow cap was opened from a shut position, the mechanical indicator for this bow cap would at the same time pass from 5 o'clock anti-clockwise through 12 o'clock to 7 o'clock, *i.e.*, through an arc of 300 deg. During some part of its movement the pointer would not be visible to anyone standing in front of the indicator.

In the torpedo tube compartment there are also six hydraulic indicators, one for each tube. The object of the indicator is to show when the bow cap is fully open. The indicator for No. 5 is in the starboard alley way about 4ft. forward of the operating levers. There is a window in the indicator, and, when the bow cap is fully open, a tell tale appears in the window and shows "safe to fire" on it. This operates on the last movement of the bow cap to fully open. The tell tale requires fairly close inspection to be seen. At other times the window is a blank.

The rear door of No. 5 tube is fitted with two levers :—(1) A small lever, or the test cock lever, and (2) a large lever or operating lever. When the test cock lever is pointing downwards the rear door is locked, and when the lever is pointing upwards the door is unlocked. There is a device on this lever invented for the purpose of indicating automatically whether the tube is more than half full of water. The device works in this way.

* Extracted from the report of the Tribunal appointed under the Tribunals of Inquiry (Evidence) Act, 1921.

In the attachment of the lever to the rear door there is a hole about $\frac{3}{8}$in. in diameter. This hole immediately adjoins a hole in the rear tube door itself. In order to open the door the lever is pushed up from the locked position to the unlocked position, and in doing this the two holes become one so that a rimer can be passed through them into the interior of the tube. The result is that any water in the interior of the tube which is above the level of the holes will come out from the tube through them. If the water in the tube is under pressure this water will spout out in a horizontal fountain. As soon as the test cock lever is pushed up into the unlocked position the two holes are not in uninterrupted communication, but there is sufficient communication between them for some water to come out. In order to prevent these holes getting blocked up a brass pin or rimer is provided. This rimer is about 4in. long, and has a brass chain attaching it to the lever attachment. It also has a "housing" in the lever attachment which is provided for it when not in use.

The tube is filled with water by opening the bow cap or by opening a cock in a tube which leads into a tank beneath the tube called the W.R.T. tank. This tank has a valve which opens direct to the sea. The tube has drain cocks at each end for the purpose of showing whether the tube is empty.

Almost immediately abaft the rear doors of the torpedo tubes is No. 25 water-tight bulkhead between the torpedo tube compartment and the torpedo stowage compartment. This bulkhead has four doors in it in two pairs. On June 1st only the port upper door was open. This door is closed by means of 18 "turnbuckles" or bolts with butterfly nuts screwed on to them. After the door is shut the bolts are placed into iron hasps with U-shaped ends fastened to the bulkhead, and the butterfly nuts are then screwed up. Stowage spring clips are fitted to the door into which the bolts and nuts are fastened until they are needed for use. The bottom of the door is about level with the centre of the middle pair of torpedo tubes.

The weight of water required to fill the torpedo tube compartment is about 45 tons, assuming the torpedo tubes to be empty and the rear doors closed. The water required to fill the torpedo stowage compartment immediately abaft the tube compartment is about 90 tons. Evidence was given at the inquiry that if the bow cap of No. 5 tube is open 30 deg. or more when the rear door is opened water would flow into the tube compartment at the rate of about 2 tons per second.

To enable the "Thetis" to communicate with surface vessels in case of her becoming submerged and unable to surface she was fitted with a number of contrivances. The most important contrivance was a device which was put out of action when she struck the bottom and was never capable of use thereafter.

The "Thetis" carried two indicator buoys. These are spherical wooden buoys about 27in. in diameter, painted red, and attached to a length of about 350ft. of wire which unwinds itself from a drum. The buoys are carried in cages sunk in the deck of the submarine and when a catch is released they float out from the cage to the surface. Each buoy has a light flag pole and flag attached to it.

The "Thetis" was equipped with three smoke candles. These are fired out of an ejector tube in the submarine and on reaching the surface produce a column of smoke which continues for 3 to 4 minutes in calm weather. In addition 25 indicator lights were on board. These are normally intended for use with practice torpedoes, but they can be fired out of the tube used for the smoke candles. They give out a light which is said to be visible for a distance of about two miles in good visibility.

In order to provide means of escape from the "Thetis" she was fitted with two escape chambers, one forward and the other aft. The forward chamber was built into the bulkhead immediately abaft the torpedo stowage compartment, and the after chamber was built into the bulkhead immediately forward of the steering compartment. The chamber is cylindrical in form and about 3ft. in diameter, and 6ft. 9in. in height. It has two entrance doors, one in each compartment between which the water-tight bulkhead is fitted. The top of the chamber has a hatch about 30in. in diameter which can be opened from inside the chamber and swung back on its hinges, and the top of the chamber is then open to the sea.

The other feature of the escape scheme is the Davis apparatus which is tied to the man's waist. Its essential feature is that it enables a man while completely submerged to live by breathing oxygen.

The "Thetis" was built at Birkenhead by Messrs. Cammell Laird and Co., Ltd., under contract with the Admiralty and was the third of her class.

Between May 2nd and 6th, torpedo equipment trials took place in the course of which the tubes, their doors, bow caps, and apparatus for opening and shutting them were all fully tested. The report of the Admiralty inspector stated that the hydraulic bow cap indicator system was to be completed and tested, and that the insides of the tubes were to be coated with bitumastic solution and finally coated with enamel. During the torpedo equipment trials No. 5 tube was used for firing purposes many times. On these occasions Commander Maguire, R.N., conducted the firing. Employees of Cammell Lairds worked the gear, and one of them, Mr. H. Eccleston, who was lost in the "Thetis," worked the bow cap levers. Commander Maguire in his evidence stated that during the torpedo firing trials on at least one occasion he saw the control lever at the neutral position after an operation had been carried out, and he then gave instructions that the levers were to be put into the open or shut position and kept there until a further order was given.

On the other hand, Mr. F. Shaw, one of the four survivors, who was present at these trials of the bow caps, and who was Eccleston's foreman, said in his evidence before the tribunal that they did not make a practice of leaving the levers in the neutral position. They always left them in the "shut" position.

On Saturday, May 13th, a man in the employ of the Wailes Dove Bitumastic Company, Ltd., started to paint the insides of the six torpedo tubes with a bitumastic solution, and another man, an enameller, then coated the solution with bitumastic enamel. All this work was done under a sub-contract with Cammell Laird.

On Sunday morning the enameller put the bitumastic solution on the insides of the six rear doors, and in the afternoon enamelled them. After enamelling the doors he smoothed off the surfaces with a blow lamp. He finished putting on the solution about midday on Sunday, started the enamelling about 3 p.m., and stopped work at 5 p.m. It is not clear from his evidence whether he also began to smooth off the surfaces with a blow lamp on Sunday afternoon or on Monday morning. He completed all the work on the doors on Monday.

When the solution was applied to the doors, the enameller took no steps to prevent the solution choking the test cock holes, but before putting on the enamel, he twisted some cotton waste into spools, soaked them in oil and used them to plug the test cock holes. He did this, he said, to prevent the waste from adhering to the sides of the hole, and to prevent the enamel entering the hole. He said that he took out the cotton waste plugs after finishing the surface with the blow lamp. The man who did the work gave this evidence before the "Thetis" was raised.

On the other hand, Mr. Grundy, an Admiralty assistant overseer, gave evidence that he inspected the rear doors of the torpedo tubes on the 16th (Tuesday), and that at the time there was no bitumastic solution or enamel on the insides of the rear doors. He also said in his evidence that he was waiting to be called to inspect the rear doors, but that he never was called.

Mr. Taylor, charge hand painter, employed by Cammell Lairds, gave evidence that the foreman of the sub-contractors who were applying the bitumastic solution and the enamel, reported to him (Taylor) on Tuesday the 16th, about 3 p.m., that the work had been completed and was ready for his inspection. Taylor examined the tubes and noticed that the insides of all the rear doors had been painted. Mr. Taylor said that he met Mr. Grundy in the torpedo compartment on Wednesday, 17th, and told him that the whole tubes in their entirety, doors, and internal surfaces, were ready for him to survey and would he kindly do so. Mr. Grundy in the presence of Mr. Taylor inspected the tubes from the rear doors which were open. On the same day a gauge was passed through the tubes. On this point I believed the evidence of Mr. Taylor. Both Mr. Taylor and Mr. Grundy gave this evidence before the "Thetis" was raised.

On the afternoon of May 31st the rear doors of the torpedo tubes were again opened and finally shut by Mr. Wolfe, the assistant foreman ship fitter of Cammell Lairds, in the presence of, and with the assistance of, Mr. Horsman, the ship fitting overseer of the Admiralty. Mr Wolfe gave evidence that when he left the "Thetis" about 4.30 p.m. all the control levers were at neutral, *i.e.*, in the vertical position.

On the same day the water-tight doors were examined and the bolts of No. 25 bulkhead doors were all found to be properly stowed in their clips.

The mechanism of the two indicator buoys was also tested. The smoke candle ejector was tested by filling the pipe with water and blowing it out. In each case the mechanism was found to be in order.

After the "Thetis" was raised she was surveyed by experts to see whether any further evidence could be obtained about the disaster.

At these surveys the following facts were ascertained:—

(1) The test cock hole in the rear door of No. 5 tube was blocked by bitumastic enamel. The hole in the rear door could not be seen from the inside, because the enamel was smoothed over it. The obstruction was knocked out of the hole from the outside by using the rimer.

(2) The rear door of No. 5 tube was fully open and engaged in its hold back position.

(3) The bow cap of No. 5 tube was fully open. The bow caps of the other five tubes were shut and their bow cap shutters were indented from contact with the ground. The bow cap shutter of No. 5 tube had no indentation.

(4) The position of the control lever for the bow cap of No. 5 tube was $\frac{5}{32}$in. or 5 deg. towards the open position. Both the opening and closing valves were fully open. The valves of the other five levers were fully open.

Obstructions were found in the test cock holes of Nos. 3 and 4 rear doors—bitumastic enamel in No. 4 and probably mud in No. 3.

After the surveys had been completed the bow cap control lever panel containing the lever for No. 5 torpedo tube was removed and tested. The result of the test was that oil did not start to pass through the opening valve until the lever had been moved another $\frac{7}{32}$in. towards open beyond the position in which it was when first seen after the accident. In other words, the lever had to be $\frac{5}{32}$in. plus $\frac{7}{32}$in. or $\frac{3}{8}$in. towards open from the neutral position before the bow cap started to creep open, and when found was therefore in a safe position.

CAUSES OF THE DISASTER

(1) *The blocking of the test cock of No. 5 rear door.*—The blocking of the test cock with bitumastic enamel, and the failure of anyone to notice it, played an important part in producing the disaster. The enameller said he first put a plug in the hole in the rear door, but no one else realised the danger. Indeed, before the "Thetis" was raised, and the obstruction was found, evidence was given before the tribunal to show that it could not happen. When the rear doors were surveyed after the "Thetis" was raised, not only No. 5 test cock but No. 4 test cock also was blocked by bitumastic enamel. If the enameller put in the plug, it must have fallen out while he was smoothing over the enamel with the blow lamp.

By some perverse mishap, the enameller did not take sufficient care to see that the test cock hole was kept clear of bitumastic, the Admiralty overseer did not use the rimer, Lieutenant Woods did not use it, nor anyone else from May 15th to June 1st.

(2) *The opening of the rear door of No. 5 tube when the bow cap was open.*—The opening of the rear door was harmless with the bow cap shut; with the bow cap open it was suicidal. This act was the immediate cause of the disaster. Lieutenant Woods opened the rear door to satisfy himself that the tube was empty, and the bow cap was water-tight. He was convinced that the bow cap was shut because (i) no water came out of the test cock (the test cock being blocked). (ii) Mr. Robinson, Cammell Laird's foreman, told him that Nos. 5 and 6 tubes were not meant to be full. (iii) He had seen the mechanical indicator at "Shut," and (iv) Leading Seaman Hambrook had told him the control levers were at "Shut."

The evidence about the opening of the rear door is as clear as the evidence about the opening of the bow cap is obscure. There is no direct evidence as to why, when, or by whom the bow cap was opened.

In this problem the established facts are few, and the theories are many.

Three assumptions appear reasonable. One is that the bow cap telemotor operating mechanism, and the bow cap mechanical indicator were in proper working order. They worked properly during their many trials before the accident; they worked properly after the "Thetis" was raised.

Another assumption is that No. 5 tube was empty and the bow cap closed before any steps were taken to put the trim on the "Thetis" in the basin before she started out on June 1st.

The third assumption is that skilful and careful men working under normal conditions and without the stress of undue haste or fatigue do their work with skill and care.

There seems to have been some misunderstanding between those engaged in putting the trim on the ship and the officers in charge of the dive whether No. 5 tube was meant to be full, or was full, or not. It is possible, but improbable, that shortly before Lieutenant Woods opened the rear door someone opened the bow cap in order to fill No. 5 tube for trimming purposes without the knowledge of Lieutenant Woods and left the bow cap open by mistake.

If this is not the reason why the bow cap was opened and left open (and opened and left open it certainly was), the only explanation appears to be a manipulation of the lever towards the open position at a time when the manipulator did not realise that power was thereby being applied to the bow cap, or a creeping open of the bow cap, when the power was turned on to the bow cap.

The next question to consider is—When was the bow cap opened ?

It is unlikely that this happened before the power was turned on at Lieutenant Wood's request not many minutes before the accident, for the very purpose of being able to open the bow caps, if necessary, to submerge the "Thetis." There was evidence that if the bow cap had been open for a considerable time while Lieutenant Woods and those under him were in charge of the tube compartment they would probably have noticed it for certain technical reasons. Moreover, if the evidence of Lieutenant Woods is believed, that he inspected the mechanical indicator of No. 5 tube and saw it was at shut, after he had asked for power to be turned on, the bow cap could not have been open at the time of his inspection. Lieutenant Woods was a clear, candid, and completely honest witness. His observation of the test cocks of the other rear doors, so far as it can be tested by their condition when the "Thetis" was raised, was close and accurate. It is likely that he would inspect the mechanical indicators of the bow caps before opening the rear doors to satisfy himself that they were at shut. True, No. 5 indicator is not easy to observe owing to its low position and obscuration by a cross bar, but it can be clearly seen by anyone who goes forward to look at it, and Lieutenant Woods was emphatic that he did so.

I am satisfied that he examined the mechanical indicators, and that he then saw No. 5 mechanical indicator was at shut, after he had asked for power to be turned on to the bow caps.

In my view the observation of No. 5 mechanical indicator by Lieutenant Woods in its shut position establishes that the bow cap was opened after he made his examination and he requested the power to be turned on, but establishes no more than that. There is no other evidence which throws any light on the question as to when the bow cap was opened, except, perhaps, the evidence of Lieutenant Coltart that he saw bubbles of air just forward of the stem of the "Thetis" almost immediately before she finally disappeared. Bubbles of air would appear on the surface if an empty or partially empty tube was suddenly filled by opening the bow cap.

Lieutenant Coltart said that the air bubbles which he saw could have been caused by the bow breaking surface, or by the forward tank being blown or by air in the torpedo tubes. I do not think that his evidence throws any light on this question as to when the bow cap was opened.

The answer therefore to the question: When was the bow cap opened ? is that it was opened after the power was turned on not many minutes before the accident but that there is no reliable evidence establishing the time more precisely than that.

It is possible, and this seems the least improbable theory, that the bow cap crept open; that the creep started when the power was turned on at the request of Lieutenant Woods and continued until the bow cap was wide open and that the lever was then put into the neutral position in which it was found after the "Thetis" was raised.

Possibly, during the morning when the power was shut off the lever, and in consequence the lever was easy to move, and men were moving about in the tube compartment, No. 5 lever was moved towards the open position sufficiently for the bow cap to start creeping open as soon as the power was turned on. The alley way in which the panel of levers is fixed is so narrow that a man has to walk along it sideways. This explanation, however, involves the conclusion that Leading Seaman Hambrook did not put the lever effectively to shut or find it at shut, after the power was turned on to it, and that he must have put it from the creeping position to the approximately neutral position in which it was subsequently found. It also involves this, that Lieutenant Woods inspected the mechanical indicator before the power was in fact turned on to No. 5 bow cap.

It may be that this theory also is not the right one. The truth may lie in some fact which has escaped all those who have tried to solve the problem.

South African Engineering Notes

(By our South African Correspondent)

Railway Development

THE Railway Lines Revision Committee has completed its work of drawing up a comprehensive programme for co-ordinating all aspects of the union's development by means of railway construction. This includes co-ordinating the industrial, commercial, agricultural, and civic requirements of the country's general development far into the future. A programme of railway construction to meet those requirements, chiefly by linking up dead ends of existing lines and by building connecting links between them is proposed. When the Committee was appointed its investigation was intended to play an important part in the £20,000,000 development scheme, spread over five to ten years, which was announced by Mr. O. Pirow, as Minister of Railways, in 1938. Now that a state of war exists, the Committee will probably recommend that no large-scale construction be undertaken at present. The Committee, it is understood, has gone into the question of cost of materials and found that it would be impossible to buy the necessary materials if construction were undertaken. Apart from the difficulty of obtaining steel rails economically, it would be almost impossible to obtain the rolling stock to use on them, and to construct the necessary bridges and buildings. On the other hand the programme on which the committee will make recommendations will be essentially a long-range one, and will be intended to serve as a guide in a few years' time when the State will be eager to take advantage of many forms of construction.

State Aid for New Industries

The Great War was responsible for a huge expansion of the industries of the Union—in 1915–16 there were 3998 industrial establishments registered. In 1936–37, when the latest census was taken, there were 9987, while the number of employees had risen from 101,176 to 332,768. It is confidently expected by commercialists and industrialists, and indeed by all sections of the population that the present war will provide at least as great opportunities. The Union Government has the same belief, and has already taken measures calculated to give the maximum assistance in the expected development. A commission has been set up known as the Commission for Industrial and Agricultural Requirements. This Commission has been directed to investigate the possibilities of industrial and agricultural expansion in South Africa. Its aim will be to indicate where new sources of commerce and industry offer and chances for expansion exist. A complementary body to this is the Industrial Development Corporation which the Government has set up. The main proposal of this body is to set up a state bank to advance loans to new industries. The Corporation has been brought into being with the intention of assisting only sound ventures which may be established during wartime, and which can be expected to survive as permanent assets in the industrial fabric of the country.

Railways and Harbours Improvement Schemes

The large expenditure upon measures for the defence of the Union of South Africa is not being allowed to hinder progress upon the big schemes on which work is now proceeding to improve the Union's harbours and railway systems to meet all anticipated requirements, at a cost of £12,690,696. The schemes are designed not only to cater for the phenomenal increase in demand for transport and shipping facilities since 1934, but to meet requirements for the next decade. The present Government programme includes expenditure of £8,631,416 on harbours and £3,935,696 on railways. Of this £2,065,000 is being spent on improving the Rand railway system. A few of the harbour development schemes are nearing completion. The rest are well under weigh. They include improvements at Cape Town, Durban, Port Elizabeth and East London. A sum of £3,130,916 is being spent on extending the foreshore at Cape Town and reclaiming and providing new berths. At Port Elizabeth work on No. 1 Quay in the enclosed harbour is almost complete. The cost of this scheme is £2,093,653. Bulk oil facilities are being provided at a cost of £55,088. There will be special berths for tankers. In East London the south breakwater has been extended by 1000ft. at a cost of £219,550, and work is proceeding on the turning basin, mail boat quay and sheds at a cost of £586,872. In Durban more than £2,600,000 is being spent on additional deepwater berths, the construction of a new marine airport, eliminating the cant on the north pier, and the building of a new floating dock. This is almost complete, and is costing £214,884. Nine four-ton cranes and one ten-ton crane have been erected and one of the new cargo sheds completed.

Railway improvement is equally comprehensive. The Eastern Cape main line is being straightened out and provided with tunnels and new bridges at a total cost of £1,800,000. Of this, £1,610,000 is being spent on the Amabele–Imvani section of the Queenstown line. In Natal, the Rossburg–Hillcrest line is being electrified and on the Rand work on electrifying the Canada–Booysens–Village main line is nearing completion. The biggest transformation is on the Rand where the new goods and marshalling yards at Prospect is a big item in the £200,000 programme. At Krugersdorp the goods yards have been remodelled and the line is being deviated, new subways to eliminate level crossings excavated, and bridges built. The Rand mineral line has been doubled and extended both ways to provide a double track line from Jupiter, near Germiston, to Bank on the West Rand. This line will take most of the Rand's heavy goods traffic from next year, leaving the main line for passenger traffic. The line from Johannesburg to Germiston will have a fifth track to reduce congestion. Twelve railway bridges and several subways have taken the place of level crossings in the city, and other level crossings are being eliminated on the East and West Rand. The New Crown-Langlaagte line will be opened as soon as the signalling system is completed.

War Affects Sewerage Plans

The sewerage plans for the northern suburbs of Cape Town may be delayed owing to the war, although it is generally admitted that these villages are in great need of adequate drainage. Big sums are involved, for even only two places, Goodwood and Parow, will have to borrow at least £90,000 each before the work can be undertaken. Several proposals and counter-proposals for a sewerage scheme have been made. It has been suggested that a farm should be bought for the construction of a disposal works. Another suggestion is that Cape Town shall extend its main sewer and that the northern suburbs link up with it. The necessity for a scheme is fully realised, but there are doubts whether the local bodies could afford to pay the higher costs which will be inevitable owing to the outbreak of war. The pipes, for example, would have to be imported, and their price would be considerable higher. Also a higher rate of interest would have to be charged on borrowed money. Formerly loans could be raised at 3½ or 4 per cent., now the rates are increased to 4½ to 5 per cent., and borrowers will be lucky if they can get sufficient money at even these rates.

National Roads Construction

The National Road Board is hoping that the war will not interfere with its programme, which aims at an expenditure of £3,500,000 during 1940. If there was no war the road construction scheme would be completed up to the gravel standard by 1943, and the total cost of the scheme would have been £22,000,000. Under present conditions, however, it is impossible to estimate the total cost or to foresee how the war will affect the Board's plans. It is not now thought that the scheme will be completed by 1943. The mileage completed and under construction at the end of 1939 was 2000, exclusive of existing bituminous surfaced roads still to be improved to national road standard. The 2080 miles are open to traffic. The total mileage of the completed survey is 3476 miles, of which 906 miles were completed during 1939. In addition the field work has been done on most of the balance of 5400 miles of recommended national road. The total number of bridges constructed since the scheme began is 187, excluding 78 under construction. One hundred and six bridges were completed during 1939. The total distance of completed gravel road is 1207 miles, the first layer of gravel has been placed on 566 miles, and 310 miles represents what is technically known as completed formation. The equivalent mileage of completed gravel road is 1800 miles, of which about 650 miles were completed during 1939. Of the 739 miles of bituminous surfacing completed, 337 miles were accomplished during 1939. The progress of the construction of bituminous surfacing is not very impressive, but lack of funds compelled the Board to request the provinces to slow down construction of such surfacing. Very good progress was being made with bridge construction until the shortage of steel due to war conditions began to hamper progress. At one time it was anticipated that bridge construction would soon have been well ahead of the formation.

A Start on New Graving Dock

The agitation for a start to be made on the planned graving dock for Cape Town has been so far successful that the Minister of Railways and Harbours has promised to take the first steps necessary. If funds are available, he states, the Government will proceed with the filling in of the land required for the dry dock as soon as possible. This work, he says, will cost about £94,000, and he is considering placing £20,000 on this year's estimates for the purpose.

Carriage Body Lifting Cranes

THE Great Western Railway Company has established a centre for the repair, lifting and maintenance of carriage stock adjoining the old Rhymney Railway carriage and wagon shop at Caerphilly. A new building comprising two bays, each 424ft. long by 72ft. wide, has been erected. One bay is 19ft 6in. high to the eaves and is used for carriage painting, and the other, 32ft. to the eaves, is the lifting shop, which is also equipped with wheel turning and grinding lathes and journal polishing machines.

The lifting shop, which has three roads for carriages and two roads between them for wheels and bogies, is served throughout its length by the two electrically driven overhead travelling cranes shown in the accompanying half-tone engraving and drawing.

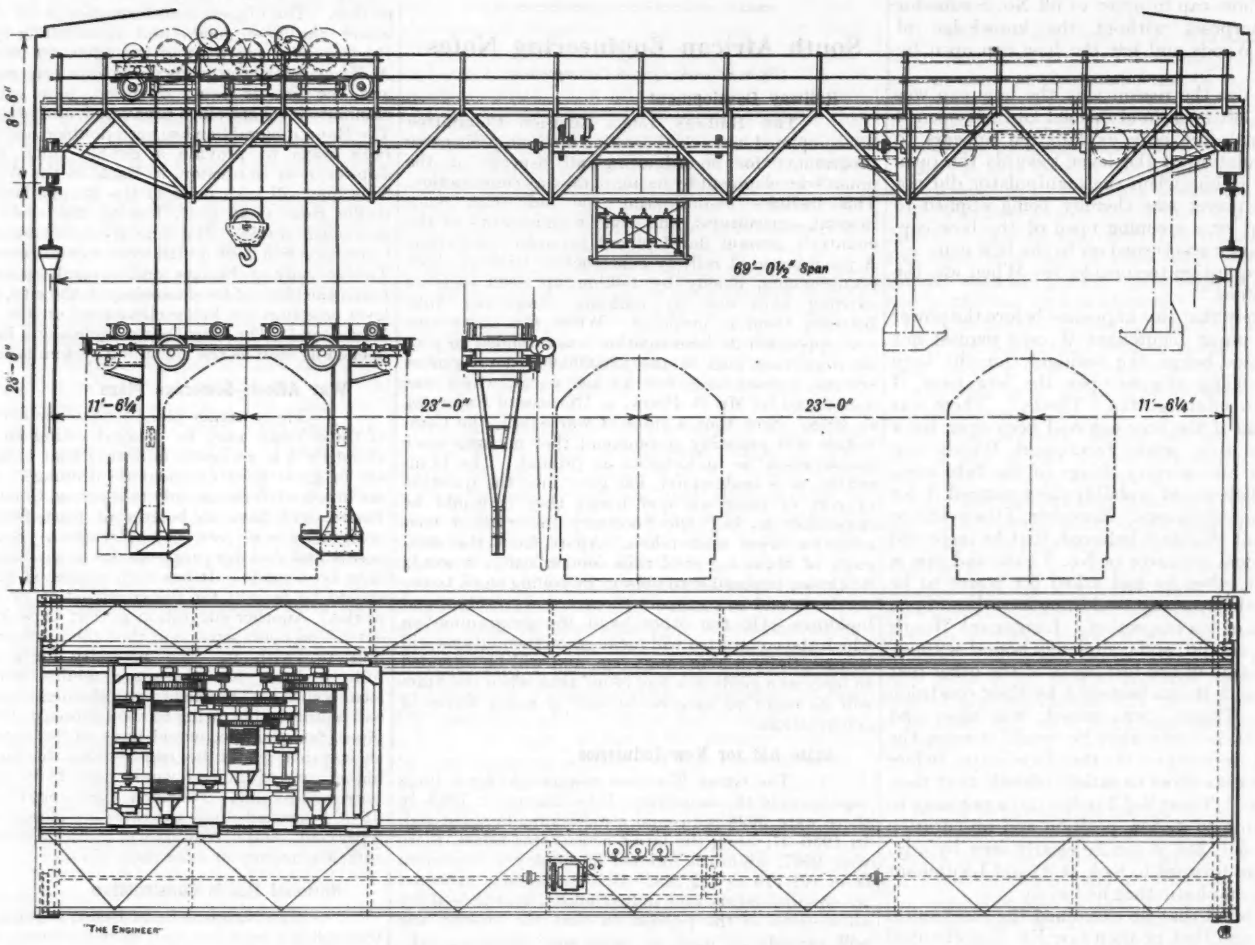
Each crane consists of a latticed girder bridge, about 69ft. across, carrying a twin-barrelled crab. Longitudinal travel of the bridge is effected by a 20 B.H.P. electric motor running at 725 r.p.m. and geared down to give a travelling speed of 200ft. per minute. The twin barrels of the main hoist of the crab are driven by a 27·5 B.H.P. motor running at 725 r.p.m. geared down to give a speed of 10ft. per minute. Suspended from these barrels on eight parts of rope, each barrel winding two parts, is an adjustable carriage lifting beam, which consists of a horizontal member and two vertical lifting arms. Sideways adjustment of the lifting arms is effected by a hand chain operated gear from the floor level, the adjustment being symmetrical about the centre of the beam. The main hoist is fitted with an overwind switch, a solenoid brake with hand release for gravity lowering, a centrifugal brake to limit the lowering speed, and an emergency hand brake mounted on the barrels. The cross-traverse motion of the crab on the bridge is effected by a 10 B.H.P. motor geared down to give a speed of 85ft. per minute.

An auxiliary hoist, driven by a 15 B.H.P. motor, fitted to the crab is capable of lifting 10 tons at a speed of 15ft. per minute, the load being suspended on an ordinary snatch block and hook carried on four falls of rope.

Platforms along the whole length of the bridge are carried on auxiliary girders on the outside of the main girders and from one of these auxiliary girders, in the centre of the span, is suspended the operator's cage.

When a carriage is dealt with the following procedure is adopted:—The cranes are positioned one at each end of the carriage and the two lifting beams are lowered with their arms on each side but clear of the body. The arms are then closed in on the carriage until lifting lugs projecting from their lower ends are beneath the solebars. Sideways adjustment permits the lifting lugs to be inserted under a solebar at a point near the bogie centre, and ensures that the upward lift on the solebars is quite vertical. This arrangement prevents racking or straining the carriage body and the underframe. On the hoisting motion of both the cranes the body is lifted clear and suspended at four points. The bogies are then wheeled clear and the coach body lowered on to trestles. The auxiliary hoist on the crab is then used to lift the bogies on to the adjoining track where the wheels are removed and taken to the machining section of the shop.

We are indebted to Mr. C. B. Collett, the chief mechanical engineer of the Great Western Railway Company, for the description of these cranes, which were built to the company's specification by the Wharton Crane and Hoist Company.



ARRANGEMENT OF CARRIAGE BODY LIFTING CRANES

CRANES IN OPERATION

NICKEL CONSUMPTION.—In his report of the business of the International Nickel Company of Canada Ltd., for the year 1939, Mr. R. C. Stanley said that the nickel consumption of the world during the year was estimated at the record figure of 256 million lb. The company's nickel sales were over 210,194,000 lb., a new high record, and its copper sales totalled 324,851,000 lb. It was estimated that during the year the world consumption of the platinum group of metals was about 500,000 oz.

QUANTITATIVE SPECTROGRAPHIC ANALYSIS.—A review of the published work on quantitative spectrographic analysis with the microphotometer, by Mr. D. M. Smith, has just been published by the British Non-Ferrous Metals Research Association. Rapid progress in quantitative spectrographic analysis during the last few years has been very largely due to the introduction of the microphotometer. This instrument provides a means of determining the relative blackenings of the lines used in the analysis with a precision far superior to that of visual observations by even a trained worker. As a result of the much improved accuracy of measurement now available, the standardisation of electrical and optical conditions for routine analysis has been shown to require more rigid control than was formerly considered necessary. It is with the nature and control of the variables encountered in the standardisation of technique that this report is mainly concerned. Data for the analysis of alloys of aluminium, copper, lead, magnesium, nickel, tin, and zinc are summarised in tabular form, with reference to a bibliography of 54 publications. This report forms the first of a series; succeeding ones will deal with experimental contributions to the subject from the Association's laboratories.

Rail and Road

RETIREMENT OF MR. F. PICK.—With the expiry of his seven years' appointment with the London Passenger Transport Board, on May 18th, Mr. Frank Pick, the vice-chairman, intends to retire. He was appointed joint assistant managing director of the companies forming the Underground group towards the end of the last war and took full administrative control in 1921. He was appointed vice-chairman of the Board on July 1st, 1933.

MATERIALS FOR MOTOR VEHICLE MANUFACTURE.—On April 5th there came into force a new scheme providing for the issue to motor vehicle manufacturers of licences to acquire iron and steel. The scheme, which is being operated by the Society of Motor Manufacturers and Traders, is intended to meet overseas and home demands for civilian transport and is of particular importance from the point of view of the export motor trade.

ANOTHER VEHICULAR TUNNEL FOR NEW YORK.—Arrangements are reported to have been completed and plans are being prepared for an early start on the construction of another vehicular tunnel for New York. It will consist of twin tubes, carrying 21ft. wide roadways, from the Battery in Manhattan to Hamilton Avenue in Brooklyn. The chief engineer of the New York City Tunnel Authority states that excavation of the first shaft will begin in May in Brooklyn. About 81 million dollars have been allotted for the construction of the tunnel.

EX-LONDON AND NORTH-WESTERN LOCOMOTIVES.—Another London, Midland and Scottish Railway locomotive type has recently become extinct with the withdrawal of the two surviving engines Nos. 6790 and 6824 of the former London and North-Western Railway 4–4–2 passenger "6ft. Precursor tank" class. Fifty engines of this type, which in most respects was a tank version of the well-known "Precursor" 4–4–0 express engines, were built at Crewe Works from 1906 onwards, and upon the formation of the London, Midland and Scottish Railway became that company's Nos. 6789–6829, Power Class 3. Prior to the introduction of the London, Midland and Scottish standard 2–6–4 tank engines, the "Precursor tanks" undertook a considerable share of suburban duties in the Euston and Broad Street area.

LOCOMOTIVE BOILER WATER TREATMENT.—The annual report of a committee of the American Railway Engineering Association, which is investigating the cause and remedy for pitting and corrosion of locomotive boiler tubes and sheets was recently presented at the Association's meeting in Chicago. In discussing methods of preventing embrittlement, the committee stated that on locomotives already built and in service the simplest and least expensive remedy seems to be water treatment. The use of sodium sulphate as a means of preventing embrittlement is given consideration, but it is pointed out that plant and laboratory tests with a detector which has been developed for determining the embrittlement action of boiler water have not confirmed the belief that this chemical is effective for the purpose. However, the committee pointed out that the search for a material in the field of organic chemicals has met with some degree of success, and went on to say that the use of lignin has proved effective. Quebracho, another organic compound, has been found suitable in the laboratory for preventing intercrystalline cracking within a certain pressure range, but it is pointed out that this chemical is probably too expensive for use in locomotives.

THE LAST OF A WELL-KNOWN CLASS OF BRITISH LOCOMOTIVES.—After nearly half a century of service, a well-known British locomotive type has passed from the active list with the withdrawal by the London, Midland and Scottish Railway Company of engine No. 17925. This was the last working survivor of a class of fifteen engines that in 1894 introduced into this country the 4–6–0 wheel arrangement, which in its more powerful forms is still the most extensive wheel arrangement for British express locomotives. Christened the "Jones Goods" after their designer, Mr. David Jones, No. 17925 and her sister engines represented in 1894 the largest type in Britain, although their total weight of 94 tons was not much more than half that of the heaviest and most powerful L.M.S. locomotives of to-day, the "Princess Coronation" type. The "Jones Goods" were built for freight and passenger duty on the heavy gradients of what is now the Highland section of the L.M.S. north of Perth, and the whole of their working lives was spent on this section, which includes the highest main line in Britain—1484ft. above sea level in the Drumochter Pass. The pioneer engine of the series, restored to its original livery, is being preserved for its historic interest at St. Rollox, Glasgow.

HIGH-SPEED LOCOMOTIVE CONNECTING RODS.—A detailed study has been made by Mr. M. W. Davidson of the United States on the flexural or "whip" stress which develops in a locomotive I-section connecting rod and also an examination of the total tensile stress which results when the whip stress is combined with that due to the inertia of the reciprocating parts, the fraction of the rod itself, the steam force, and the component of the normal guide reaction which is due to the inertia of the rod. The results of the investigation were presented to the Railroad Division of the American Society of Mechanical Engineers at its recent annual meeting. The particular connecting rod, reciprocating weights, general dimensions, and quantities used in the study were from a class F–3, Chicago, Milwaukee, St. Paul, and Pacific Railroad locomotive, having cylinders 23in. in diameter and 28in. stroke; driving wheels 79in. diameter; reciprocating parts weighing 1126 lb; I-section connecting rod, 116½in. between wrist-pin and crank pin centres, and weighing 877 lb. The results of the study show that for 100 m.p.h. the maximum whip stress that can be expected in a conventional I-section locomotive connecting rod is about 8500 lb. per square inch, and that the maximum combined tensile stress will be 14,000 lb. per square inch. As the elastic limit of the usual carbon steel of which these rods are made is about 48,000 lb. per square inch, the factor of safety with this as base is about 3·5. If 3½ per cent. nickel steel of the same carbon content were used for the rod material, the elastic limit would be about 60,000 and the factor of safety with this as base would be 4·38.

Miscellanea

BRITISH MINES AND QUARRIES IN 1938.—The report for 1938 of the Mines Department on the metalliferous mines and quarries in this country shows that during the year the total ouput of minerals from quarries more than 20ft. in depth totalled nearly 104 million tons and from metalliferous mines over a million tons. There were 76,128 persons employed in the quarries and 12,457 in the mines. Accidents in the quarries caused 67 deaths and 303 injuries and in the mines 14 deaths and 42 injuries.

A NEW SMOKE AND DUST ELIMINATION PROCESS.—It is reported that a new process for the elimination of smoke and dust by means of sound waves has been developed by the United States Bureau of Mines. The apparatus sets up high frequency sound waves which cause dust and smoke particles to form into flakes and fall from the air as it passes through a small chamber. Sound waves, it is claimed, can be created inexpensively on a large scale, and it is expected that in time every important chimney will have such a contrivance installed.

ELECTRIC LIGHT FITTINGS PRICE INCREASE.—At a joint meeting of the Industrial and Commercial and Ornamental and Decorative Sections of the Electric Light Fittings Association held at Birmingham recently, it was unanimously resolved that in view of the continued increasing cost of raw materials, the recent advances in the cost of labour and extra overhead expenses which all members have to face as the result of war contingencies, the members of these two sections be authorised to apply from April 1 next certain specified minimum full-scale advances, to their pre-war published prices ruling at September 3rd, 1939. The advances range from 10 to 17½ per cent. It should be noted that direct Government tenders or contracts are outside the scope of the above provisions.

DESULPHURISATION OF PIG IRON.—The United States Bureau of Mines has issued a report on a process for the desulphurisation of pig iron with calcium carbide. This process, instead of the usual reaction by which final desulphurisation is accomplished in the blast furnace, depends on the reaction between solid calcium carbide and liquid iron. Adequate dispersion of the carbide is essential in the process and a mechanical dispersing unit for adding finely ground calcium carbide to large quantities of molten cast iron has been developed. In tests one-ton lots of molten iron were desulphurised and the metal then used for the production of grey iron castings. It was found that the sulphur content of the iron could be reduced from about 0·09 to 0·01 per cent. by the addition of 15 lb. of calcium carbide per ton of metal. The amount of sulphur eliminated depended upon the size of the carbide particles and the most efficient results were obtained from sizes between those passing through 48 mesh to 200 mesh.

PROTECTIVE COATINGS ON UNDERGROUND PIPE LINES.—It has been decided to permit any interested person to be present when a number of working pipe lines protected by different coatings are exposed after being buried for ten years at test sites in the United States. This piece of research is being conducted by the American Petroleum Institute and the National Bureau of Standards and a final report will probably be issued later. At each of thirteen test sites there are fourteen different coatings on each of two 12ft. sections of working pipe line, and at fifteen sites there are about forty-six varieties of coatings applied to 2ft. sections of 3in. pipe. There are also several sections of uncoated line and 3in. pipe at each site. The following tests are to be made:—soil resistivity measurements; current on the working lines; pattern tests for the location of pinholes; coating resistance (electrical); inspection of coatings in accordance with a code; and measurements of pit depths on bare and coated specimens.

COOPERS HILL WAR MEMORIAL PRIZE AND MEDAL.—This prize, which was founded by members of the Royal Indian Engineering College, Coopers Hill, in commemoration of members of the college who fell during the last war, is awarded annually by the Institution of Civil Engineers and triennially in turn by the Institution of Electrical Engineers, the School of Military Engineering, Chatham, and the School of Forestry, Oxford. It consists of a bronze medal; a parchment certificate of award; and a money prize of the value of about £20, and is awarded for the best paper on a professional subject selected by the council making the award. The triennial award falls this year to the council of the Institution of Electrical Engineers, which has decided to invite members to submit for consideration a paper on any subject coming within the scope of electrical science or electrical engineering and their applications. Papers submitted must be specially written for the purpose of the competition and reach the secretary of the Institution not later than October 1st, 1940. Only corporate members of the Institution who were under 35 years of age on January 1st, 1940, are eligible.

INSTITUTE OF METALS MAY MEETING.—A general meeting of the Institute of Metals will be held at the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W.1, at 2 p. m. on Wednesday, May 8th, when the folowing papers will be presented for discussion:—"The Influence of Alloying Elements on the Crystallisation of Copper. Part II.—Large Additions and the Part Played by the Constitution," by Dr. L. Northcott; "The Structural Changes in Copper Effected by Cold Rolling and Annealing," by Dr. Maurice Cook and Mr. T. Ll. Richards; "The Ageing of High-Purity 4 per cent. Copper-Aluminium Alloy," by Dr. Marie L. V. Gayler and Mr. R. Parkhouse. The meeting will be followed by the Thirtieth Annual May Lecture, which will be given at 7 p.m. by Professor J. D. Cockcroft on "The Cyclotron and Its Applications." At the recent annual general meeting of the Institute, Lieut.-Colonel, The Hon. R. M. Preston was elected President. As vice-presidents there were elected Dr. S. F. Dorey, Engineer Vice-Admiral Sir George Preece, and Mr. A. J. G. Smout. The new treasurer is Lieut.-General Sir Ronald Charles who replaces Mr. John Fry who has retired after sixteen years' service which has been recognised by the Council's award of an Institute Fellowship. Five new members of Council are Dr. W. E. Alkins, Mr. G. L. Bailey, Captain F. C. Braby, Colonel P. G. J. Gueterbock, D.S.O., and Professor D. Hanson.

Air and Water

PENARTH DOCK.—A scheme is being prepared by the Penarth Council for the re-opening of Penarth Dock which during the past four years has only been used by ships laying up.

TURKISH SHIPBUILDING ORDERS.—It is reported that an agreement in principle has been reached between the Turkish Government and the representatives of Swan, Hunter and Wigham Richardson, Ltd., for the construction of eleven merchant vessels at a cost of over two million pounds.

ROYAL MARINE ENGINEERS.—The *London Gazette* announces that a corps of Royal Marine Engineers is being established in order to carry out certain urgent works. Officers and men of the Royal Marines employed in the new corps will receive their normal rates of pay and allowances whilst tradesmen and pioneers will receive pay at the rates authorised for corresponding grades in the Royal Engineers in the Army.

CARGO SHIP BUILDING.—In his annual report, Mr. W. Westwood, general secretary of the Ship Constructors and Shipwrights Association, says that this country will shortly begin to break all records for the construction of cargo ships. Each shipbuilding yard will build one type of ship only, and this type will be one that it can construct rapidly and economically. Although these vessels will be called "emergency ships" states Mr. Westwood, they will be built to last and not suffer the fate of the "standard" ships of the last war.

THE HEINKEL 115.—The most commonly used aircraft for laying mines by the Germans is said to be the Heinkel 115. This machine is a twin float, mid wing monoplane having a wing span of nearly 73ft: and a length of nearly 57ft. Its two 850 H.P. engines give a cruising speed of about 180 m.p.h., and a maximum speed of some 220 m.p.h. With a crew of three the machine has an all up weight of nine tons and is said to be capable of carrying about a ton of bombs, mines, or torpedoes. With an effective range of 1300 miles the "115" is thought to have a service ceiling of about 21,300ft.

TERMS OF HIRE FOR CARGO LINERS.—It is reported that the terms of hire of cargo liners to the Government have been largely settled and that owners will receive monthly rates of payment covering their expenses, including crews' wages and marine insurance. The basic monthly rate, excluding insurance, is expected to be 5s. 9½d. per dead-weight ton. In addition, a depreciation allowance of 5 per cent. is to be made on building costs, while interest at a rate still to be determined will be paid on the capital employed and represented by the building costs of ships. Terms for passenger liners, oil tankers, deep-sea, and short distance cargo vessels remain to be fixed.

A SWEDISH SHIP CANAL.—Plans have been prepared by the Swedish Office of Roads and Harbours for the construction of a canal across a narrow tongue of land which juts out into the Baltic on the south coast and lies between the Baltic and the Sound (Oresund), the waterway between Sweden and Denmark. The neck of land at the mainland end is relatively narrow and the canal will have a length of about seventeen miles with a width of 330ft. at its narrowest section. The canal will be cut from a small place known as Höllviken on the Sound to the Bight of Kämpinge on the Baltic side. There is deep water on the Baltic side of the proposed canal, but an approach channel will have to be dredged on the Sound side.

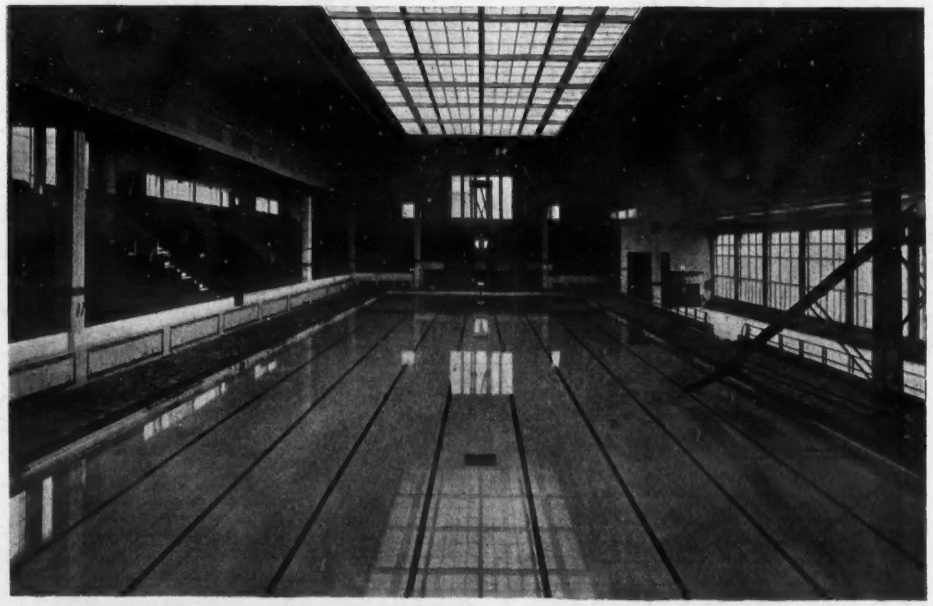
DNIEPR–NIEMEN WATERWAY.—It is reported in the Soviet Press that work has already been commenced on the construction of the Dniepr–Niemen waterway (315 miles long) which is to link up the River Yaselda, a tributary of the Pripet, with the River Shchar, a tributary of the Niemen. Through the rivers Niemen and Dniepr the new waterway will link up the Baltic Sea and the Black Sea. The waterway will pass through the Baranovichi, Pinsk, and Belostok provinces and provide these regions, cut off from important centres, with a cheap means of transport. The scheme will entail the building of thirty locks and the route has been divided into eleven sections at which preparatory work is now in progress.

TRANS-ATLANTIC AIR SERVICES.—At a recent conference, reported in *The Times*, Mr. Clive Pearson, chairman of the British Overseas Airways Corporation, said that it is not likely that a North Atlantic passenger service will be begun this year by the Corporation, but mails will be carried on this route. The mail service is expected to start soon after the base in Newfoundland is clear of ice, which is towards the end of May. The South Atlantic project of British Airways is to be held in abeyance. Meanwhile the Corporation will buy a limited number of D.H.95 aeroplanes and will maintain a constant watch on commercial aircraft development throughout the world so that at any moment it would be able, if the war permitted, to issue specifications for commercial aircraft which would be up to date.

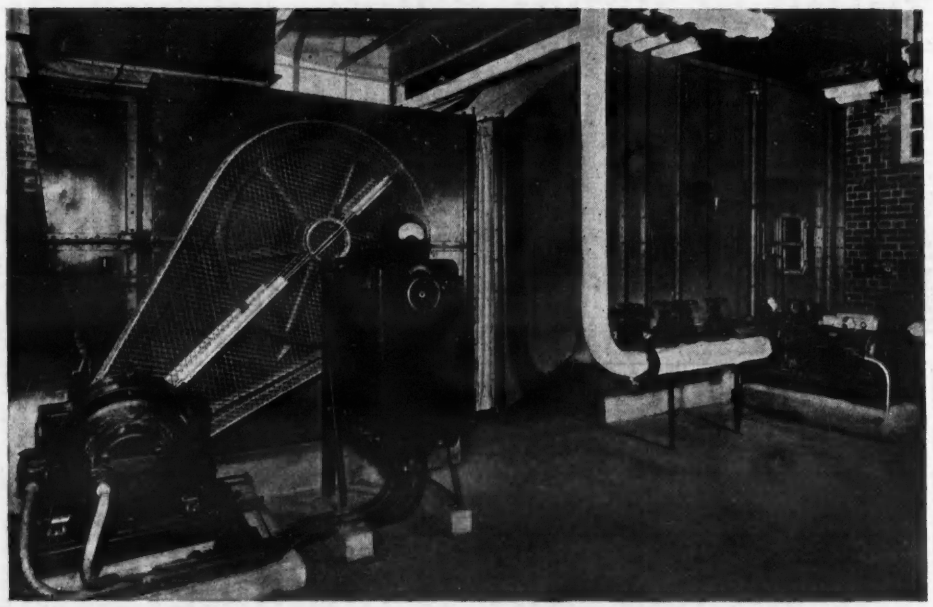
IMPROVEMENTS AT THE ROYAL VICTORIA DOCK.—According to the monthly Journal of the Port of London Authority, a further stage in the development of the Royal Victoria Dock has now been practically completed by the removal of the high banks of earth which had been a feature of the south-east corner of the dock. The site, east of the Pontoon Dock, is known as the "Mudfield," the name being derived from the fact that when the Pontoon Dock and the passage thereto from the Royal Victoria Dock was constructed about 80 years ago, the excavated material was tipped there and formed a spoil bank rising to 15ft. above dock level and extending over an area of about 14 acres. In 1936 development of the site was undertaken. A monolith quay wall was constructed to form berths with 31ft. of water for large vessels on the east side of the Pontoon Dock passage and the south-east side of the Royal Victoria Dock. The building of the quay involved the excavation of a wide cutting, the material from which was tipped on the adjacent ground. It was then necessary to dredge the large quantity of earth which lay between the quay wall and the dock, and to excavate to quay level the high ground east and south of the quay. A total quantity of about half a million cubic yards of material has been dredged.

EQUIPMENT OF THE DERBY BATHS, BLACKPOOL

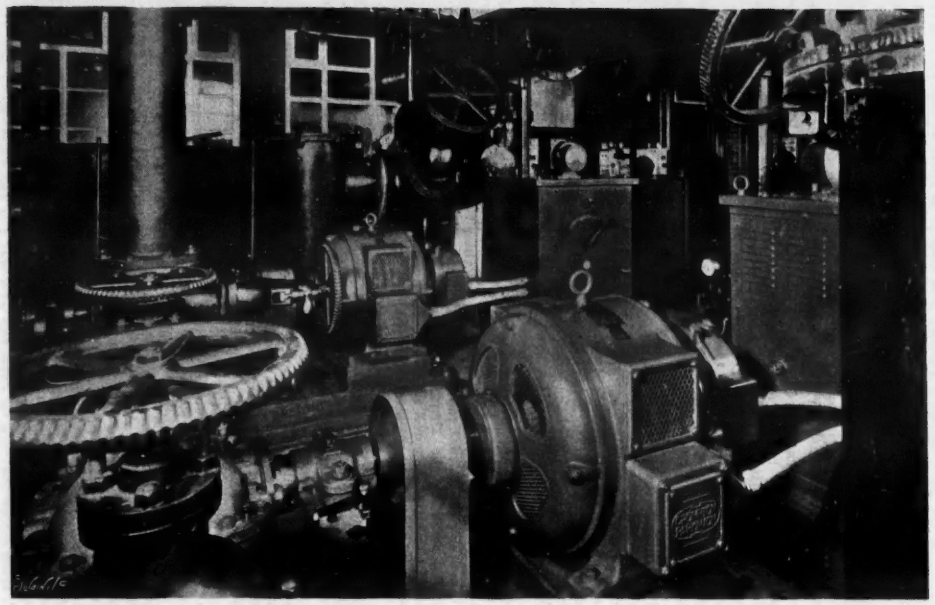
(*For description see page* 359)



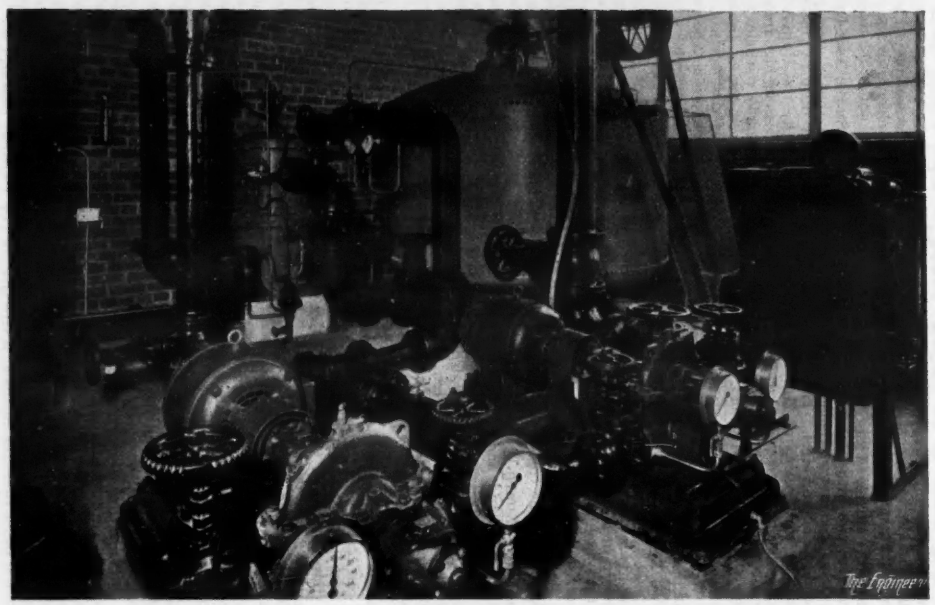
GENERAL VIEW OF THE SWIMMING POOL



AIR CONDITIONING PLANT



FILTER ROOM PUMPS AND DRIVING MOTORS



PUMPS AND FILTER FOR LEARNERS' POOL

The Engineer

APRIL 12, 1940

VOL. CLXIX No. 4396

Contents

THE ENGINEER, April 12th, 1940 PAGE

A SEVEN-DAY JOURNAL ... 341

LEADING ARTICLES—
- THE LOSS OF THE "THETIS" ... 353
- ANGLO-FRENCH TRADE PROPOSALS ... 354

SPECIAL ARTICLES—
- H.M.S. "THETIS" ... 347
- LONDON'S WATER SUPPLY. (Illus.) ... 344
- MECHANISM OF MAGNETISATION. No. IV. (Illus.) ... 342
- SCIENTIFIC INSTRUMENTS AND APPARATUS. No. III. (Illus.) 355
- ADVANCE IN IRON AND STEEL PRICES ... 360
- CARRIAGE BODY LIFTING CRANES. (Illus.) ... 350
- ELECTRICAL EQUIPMENT OF THE DERBY BATHS, BLACKPOOL (Illus.) ... 359
- OIL-ENGINED RAIL TRACTION TRANSMISSION SYSTEMS ... 360
- REFUELLING IN FLIGHT. (Illus.) ... 358

LITERATURE ... 354

NEWS AND NOTES—
- AIR AND WATER ... 351
- CATALOGUES ... 364
- FORTHCOMING ENGAGEMENTS ... 364
- FRENCH ENGINEERING NOTES ... 364
- MARKETS, NOTES AND NEWS ... 363
- MISCELLANEA ... 351
- PERSONAL AND BUSINESS ANNOUNCEMENTS ... 364
- RAIL AND ROAD ... 351
- SIXTY YEARS AGO ... 355
- SOUTH AFRICAN ENGINEERING NEWS ... 349

NOTICES TO READERS

WAR MEASURES

PUBLISHING AND ADVERTISING

THE ENGINEER is now being published at the works of William Clowes and Sons, Ltd., Beccles, Suffolk. Telephone No. Beccles 2103. All correspondence connected with publishing and advertising should be directed to that address.

EDITORIAL

All Editorial correspondence is being conducted from 28, ESSEX STREET, STRAND, W.C.2, and all articles, etc., should normally be sent to that address, but in cases of urgency messages may be sent to the Editor at Beccles.

GENERAL

The head office, 28, ESSEX STREET, STRAND, W.C.2, is open from Mondays to Fridays inclusive from 9-15 a.m. to 5-15 p.m., where classified advertisements may be handed in as usual and copies of the paper may be purchased. The office is not open on Saturdays.

PAPER SUPPLIES

With a view to the conservation of paper, readers are advised, in the interests of all concerned, to place a regular order for THE ENGINEER with their newsagent or direct with the Publisher.

*** *If any Subscriber abroad should receive* THE ENGINEER *in an imperfect or mutilated condition, he will oblige by giving prompt information of the fact to the Publisher, with the name of the Agent through whom the paper is obtained. Such inconvenience, if suffered, can be remedied by obtaining the paper direct from this office.*

*** *For Subscription rates, see page 2 of Advertisements.*

*** *All letters intended for insertion in* THE ENGINEER *or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

*** *No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.*

CHANGE OF ADDRESS

*** *Will Subscribers please note that in all advices regarding changes of address it is necessary to have* **both the old and new addresses**, *as our lists are kept alphabetically by towns. Advices of this nature should reach us by the first post Wednesday morning prior to the alteration.*

Postal Address: "The Engineer," 28, Essex Street, Strand, London, W.C.2.

Telegraphic Address: "Engineer Newspaper, Estrand, London." Telephone: CENtral 6565 (10 lines).

THE LOSS OF THE "THETIS"

ON another page we reprint from Mr. Justice Bucknill's report—issued on Thursday, April 4th—those parts which refer to the proximate cause of the loss of H.M. Submarine "Thetis" in Liverpool Bay on June 1st, 1939. That cause was the opening of the inner door of a torpedo tube on the starboard side whilst the bow cap of that tube was open. The subsequent events, including the fruitless attempts to save the imprisoned men and the ultimate salvage of the vessel, form what is, in fact, a separate history. From them much will be learnt that may prove of value in similar circumstances, but for the moment, and from the the purely technical aspect, it is of much greater importance to consider the events which led up to the accident than the events which followed it. Whilst engineers are called upon to make provision against accidents, they recognise that the adoption of safety devices which will prevent the occurrence of mishaps is of far greater moment than any devices designed to minimise the effects of such mishaps.

From this point of view it is manifest that interest centres round the construction and operation of the inner and outer doors of the torpedo tubes of submarines and the means available to the persons in charge to enable them to satisfy themselves regarding the position and condition of these two doors at any time. It will be convenient to review briefly these provisions as they affected the No. 5 tube of the "Thetis" at the time of the accident. In the vessels of her class, there are six tubes in all, three at the starboard and three at the port bow. They are placed one above the other, and No. 5 tube—that which caused the disaster—is the lowermost on the starboard side. It and its opposite number to port are always submerged. Each tube is about 21in. in diameter internally and is provided with two doors—the bow cap at the outward end and the charging door inside the torpedo room. To charge a tube the bow cap is closed, the water in the tube drained away, and the inner door is opened. The torpedo is then placed in position, the door is shut and made fast, and the bow cap is swung open until it lies fore and aft. When a submarine is going into action, torpedoes are in the tubes and their weight in that forward position gives the vessel a certain trim; but on trials without torpedoes the tubes have usually to be kept partially filled with water to give the necessary trim for diving. Now it is manifest that considerable force must be available for the opening of the bow caps, which are of large diameter and may be under considerable hydraulic head. Hence they are operated by telemotors. The valves of these motors are controlled by vertical levers about 11in. long arranged one above the other, one for each tube, in an alley way between the tier of tubes and the vessel's side. The bow cap is opened by pushing its lever forward about 45 deg. and closed by drawing it back by the same amount. In the upright or neutral position the cap is locked "open" or "shut" as the case may be. Here there is a very important fact to notice. After the "Thetis" was salvaged it was found by experiment with No. 5 lever that if it were moved forward no more than twelve degrees sufficient oil would creep through the valve to open the door slowly and if the lever were then returned to the neutral position the cap would no doubt—it is not specifically stated in the Report—remain in the position it had attained. As a matter of fact the cap was found fully open after the salvage, but it is not necessary to remind our readers that a mean opening of no more than one quarter the diameter of the tube would admit as much water as full opening. It was given in evidence that with the bow cap open 30 degrees two tons of water per second would flow through the open door—at what head it is not stated in the report. The importance of the facts that a small movement of the lever, no more than 12 degrees, is sufficient to cause the bow cap to open, and that only partial opening would admit enough water to flood the torpedo compartment very rapidly will be seen when the suggestion that the lever was moved inadvertently or otherwise and then replaced at neutral is put forward as one of the possible reasons why the bow cap was open.

We must now consider the sequence of operations that must be followed before the cap and door can be opened or closed. They are of great moment, for it is on them that reliance is placed in British submarines for the avoidance of such accidents as that which befell the "Thetis." Each of the six rams which operate the caps is connected to a pointer moving across a dial stamped "shut" and "open." The indicator of No. 5 tube in the "Thetis" is close to the floor, its bottom edge only 9in. above it, and moreover a horizontal bar immediately abaft it makes it difficult to see without deliberate effort. The pointer has a long range. It starts at 5 o'clock and moves anti-clockwise back to 7 o'clock, that is through an arc of 300 deg. as the cap opens. Unfortunately, "during some part of its movement the pointer would not be visible to anyone standing in front of the indicator." Furthermore, there are six hydraulic indicators, one for each tube, the object of which is to show when the bow caps are open. They inform the officer in charge when it is "safe to fire" and require to be observed fairly closely. But the point of greatest consequence is that these indicators do not show the position of the cap. Until the cap is fully open they give no indication at all. Did they show the position of the door the accident would probably have been avoided, for the officer in charge would almost certainly have consulted them. But, as we have said, they are not intended for that purpose, but only to show when the cap is fully open and it is safe to discharge the torpedo. We assume, for it is not expressly stated, that they are interlocked with the firing gear so that the latter cannot be used till the cap is wide open. Besides these indicators there is a further safeguard to obviate the danger of a door being opened until its corresponding cap is tightly closed. In the door there is a lever which controls a test cock with a bore three-eights of an inch in diameter. The lever moves up and down. When it is down, not only is the test cock closed, but the door itself is locked. On the other hand, when the lever is raised to unlock the door the test cock is open. In this position, and this position only, can the lever which actually opens the door be operated. Clearly this would be a perfect safeguard against the opening of the door if the cap were not closed. For if the tube were full of water under pressure a powerful jet would be driven through the cock. The importance of the safeguard is fully recognised, for a rimer for clearing each cock hangs permanently beside it and it is part of the Naval routine to use these rimers at frequent intervals. Yet despite the importance of this test cock and the usual routine the rimer was never used on the door of No. 5 tube, and when the "Thetis" was salved the hole was found to be completely closed on the inside by a layer of protective enamel. There can be no question at all that had the hole been free the accident would not have occurred. Mr. Justice Bucknill's observations on this point should be closely studied.

We have here a sequence of events and coincidences which, as so often before, piled one upon the other to make a tragedy. No one knows, and no one will ever know now, how the door came to be open; whether it was opened purposely or whether in the confined space of a narrow alley way someone inadvertently moved the lever to open and then replaced it without cognisance of what that action meant. The condition of the bow cap could have been ascertained from the indicator connected with its ram, but the indicator is badly placed, and though there is evidence that Lieut. Woods did inspect the indicator, final reliance seems to have been placed upon the positive evidence which the test cock should have given. The blocking of it was the culminating misfortune. Why it occurred and how it escaped detection are amongst those things which would almost persuade us that malign influences sometimes deliberately interfere in the affairs of man. The painter who applied the enamel declared that he took quite proper precautions to prevent enamel getting into the hole. The officer in charge having

ascertained, as he believed, by other means that the cap was closed took it for granted that the test cock was clear. Thus the calamity built itself up to the climax like a Greek tragedy. And in the end all that a High Court Judge can say after a most exhaustive inquiry is "The truth may lie in some fact which has escaped all those who have tried to solve the problem." But though we shall never know all that it is necessary to know about the order of the events and the times of their occurrence which led up to the primary cause of the disaster it would seem to be clear that the safeguards against mishap, adequate as they appear to be, are yet insufficient and that a positive lock between the cap and the door—which we believe is employed in some foreign navies—is desirable.

The Anglo-French Trade Proposals

DURING the past twenty years the production and distribution of manufactured goods and commodities have evolved in a manner that defies every sane principle of international trade. Beginning with the idea of self-sufficiency which arose out of conceptions of defence after the last war, there developed on the Continent a system of import quotas, prohibitions, rigid reciprocal exchange and barter that constituted a permanent obstacle to international trade upon which all countries depend for their well-being. The simple means of payment amongst them, by the free use of the one standard of international value that built up a prosperous foreign trade in the past, failed to meet a new and dangerous situation. So long as wars and preparations for them drive gold out of circulation new measures are required to save trade in Europe from a state of atrophy until the world can settle down again to normal business. Totalitarian countries have their own solutions involving "living room" and control by force over other nations that would enable them to create a new order in Europe to their own profit, with the elimination of gold as a factor in trade exchanges. It is useless to conjecture what what may happen after the present war. All that we know is that the world economy has changed with a vast and ever increasing extension of industrialism, which has created new conditions and problems of an intricate and perplexing character.

A solution of these problems is so closely associated with the Anglo-French industrial co-operation that the negotiations now in progress between the two Governments, and between the Federation of British Industries and the Confederation of French Employers, open up a new and encouraging outlook for the industrial future. It is not a mere war expedient, but is intended to continue after the war, perhaps indefinitely. A general plan has been prepared that represents the first practical effort to solve the economic problems of a troubled Europe. The merit of the plan lies in the fact of its being an experiment that will be thoroughly tested, and if it succeeds, as appears inevitable if mutual confidence can ensure success, it may give results of great promise. Already Great Britain and France have the means of largely increasing the volume of exchanges between them. The industrial representatives of the two countries are now arranging with different branches of the manufacturing trades for their respective participations in the agreement, assisted by a permanent Anglo-French Industrial Committee in London. The co-operation covers the British and French colonies, and may extend eventually to some, if not all, of the Dominions. As reasons for this co-operation are primarily those of production for export they make a strong appeal to French manufacturers, who are in a much less favourable position than the British to turn out goods for sale abroad. While civil production was not suspended in Great Britain on the outbreak of war, the general mobilisation in France deprived makers of men, technical staffs, and raw materials, and a large number of employers were themselves called up. This state of things lasted for about five months. The means of producing goods are now being restored under pressure of the necessity to export. That is essential for the prosecution of the war. It is to the interest of Great Britain and France that each country should export as much as possible. There are, firstly, exchanges of complementary goods between the two Empires, and a discriminating trade in more or less competitive products; secondly, the sharing of markets compulsorily abandoned by Germany in proportion to the minimum British and French exports to those markets before the war; and, finally, an agreement on questions of prices, conditions of sale, and on other aspects of uneconomical competition. The French go still further and would like each country to supply the other with a certain amount of armaments in order to allow them to release for export production some works that are engaged exclusively on war material. Another phase of co-operation relates to the supplies of raw materials, and their distribution and transport with the object of eliminating undue competition in their purchase. For some industries there may be an exchange of patents and processes and the sharing of orders for special work or the carrying out of such work in common. The idea in France is to apply to civil production the policy of complete unity of action that is working so smoothly in the economic field and in armaments, as well as in the great war effort which is being carried on with a pooling of the two countries' resources. That pooling may end six months after the termination of the war, but the trade agreement will last so long as it proves satisfactory to both countries, and the possibility of its indefinite duration is implied by its flexible character whereby it may be adapted by common consent to changing conditions. It is regarded in France as completing the cycle of war effort that will not only bring hostilities to an end but will also provide the structure for an industrial and trade recovery afterwards.

The carrying out of such a wide and comprehensive agreement would appear to offer serious difficulties if it were not for a clause in the French plan which stipulates that arrangements may be made for the specialisation of British and French industries in which one or the other has the greater facilities for production. Since the problem of developing exports began to arouse national interest in France three or four years ago, the State has taken up the position that imports must be encouraged because there can be no export trade without them, and also because import duties provide a notable contribution to the national exchequer. It was, therefore, an uneconomical policy to nurse industries that could not live without exaggerated protection. At that time the opinions of economists were not shared by industrialists whose businesses could only survive under protection when their existence was threatened by foreign subsidised exports and other abnormal devices for the sale of goods abroad. The fact that the Confederation of French Employers should have included a specialisation of industries in the plan is, therefore, of particular importance. The war has swept away baneful methods due to German initiative that threatened the destruction of legitimate trading, and the French now look to a new order of things more in harmony with old traditions. If Great Britain and France can widen exchanges of non-competitive goods by each supplying the other with what they can produce under better conditions, the way will be opened to an expanding industrial activity and trade, not only between themselves but also with foreign markets. Each country has its national characteristics, genius, and skill in particular trades that give special qualities to productions complementary to those of the other. There are consequently sufficient elements to constitute an agreement upon what may be as nearly as possible free trade principles, with necessary restrictions for competitive industries, until it is seen how far those restrictions can be removed. The co-operation plan introduces a new industrial trading policy of complete mutual understanding, confidence and organised effort in the common interest. How far its operation may extend depends upon the good will of other nations.

Literature

Jane's Fighting Ships, 1939. Edited by Francis E. McMurtrie, A.I.N.A. London: Sampson Low, Marston and Co., Ltd. Price: 52s. 6d. net.

So great has been the demand for the 1939 issue of this standard book of reference on the part of all interested in naval construction and warfare that it now appears in a second printing. Under wartime conditions the task of producing such a book was no light one, and both the editor and the publishers are to be congratulated on turning out such a volume some weeks ahead of the time scheduled for its appearance. We note with satisfaction that it is hoped to publish the 1940 edition of "Jane" at the earliest feasible date. Certainly the value of an up-to-date copy needs no stressing. To anyone who wishes to follow daily the naval events of the war, a copy of "Jane" is indispensible.

The general survey of naval construction during 1939, which was specially written by Mr. McMurtrie for our issues of January 5th and 12th, might well serve as an introduction to the volume under review, which contains an amount of new material well above the normal. Indeed there are more engravings of new ships than have appeared in "Jane" for the past twenty years. Other pictures of equal interest are those showing the changes made in the appearance of the older ships after they have been modified in construction or armament. An excellent example of such reconstruction is afforded by H.M.S. "Renown", which forms the frontispiece.

With the increasing amount of new matter, very careful attention has had to be paid to the size of the volume. It has, we note, been kept well within the prescribed limits, without the sacrifice of any essential feature. By re-arrangement of the text, and the discarding of certain non-essential features, room has been found for much new and interesting matter and additional illustrations. Pages in earlier editions which were devoted to separate summaries of the fleets of the principal powers have given place to a compact table in the introductory section showing the naval strength of the leading powers at September, 1939, completed ships only being taken into consideration. In another useful table the various changes which have been made in the present edition are set out. Capital ships, under consideration or on order, in the various countries of the world, now number thirty-four, and of this number ten, including the four British units of the "Lion" class, are believed to be designed for displacements between 40,000 and 45,000 tons.

The section dealing with the British Navy is remarkably full, although it will be appreciated that in time of war it has not been possible to give such complete data with regard to the construction of British warships as might be expected to appear in normal times. New reproductions from photographs of British ships include the reconstructed "Renown," the refitted aircraft carrier "Furious," the new 10,000-ton cruiser "Belfast," the anti-aircraft ship "Cairo," and two destroyers of the "Javelin" class, besides some of the latest motor torpedo boats. In fact all fresh information which was published up to September 2nd has been incorporated, while war losses up to the date of going to press have been indicated.

A very full account of the latest French naval construction is given, and the particulars regarding the latest additions to the German fleet are surprisingly complete. In the American section, a notable addition is the new cruiser "Wichita." Additions made during the year to the fleets of the Netherlands and of the Scandinavian countries are duly covered, and in particular we note that the Swedish section has been very thoroughly revised. Other outstanding features include the fresh facts recorded concerning the Italian and the Japanese Navies, and particulars of the Royal Thian Navy (formerly known as the Siamese Navy) and of the Philippines. In this particularly difficult time, the editor and all who have helped him are to be congratulated on the timely appearance of such a valuable volume, the regular production of which is undoubtedly of great national service.

EXTRACTION OF OIL FROM PEAT.—A process has been developed in Finland by a Mr. Olavi Komppa for the extraction of oil from peat which is said to be considerably cheaper than the obtaining of oil from coal by distillation.

Sixty Years Ago

SUPERELEVATION

ON February 23rd, 1880, a Metropolitan-District train from Mansion House to Richmond was derailed close to Gunnersbury Station. The train consisted of a tank-engine—running fire-box end first—and eight coaches, all fitted with the Westinghouse non-automatic brake. At the time of the accident the train was running at a speed of about twenty miles an hour. All the coaches except the last followed the engine off the rails. No one was seriously hurt, but the Board of Trade appointed General Hutchinson to inquire into the mishap. In our issue of April 9th, 1880, we criticised his conclusions. The derailment occurred while the train was running over a curve of about 33¼ chains radius. Normally the outer rail should have had a superelevation of 1½in., but the inspector believed that recent heavy rains had caused the sleepers to sink, and that the cause of the derailment was the absence of sufficient superelevation to meet the speed at which the train was travelling. We took exception to this finding. Many engineers in this country and abroad held, we said, that the raising of the outer rail on a curve was a complete mistake and were laying their curves without superelevation. Various formulæ existed for calculating the superelevation supposed to be required to meet specified conditions, but it was safe to say that not one curve in ten had the amount of cant dictated by theory. Law's formula—as used by Brunel—assumed that on the 4ft. 8½in. gauge no superelevation was required on curves of a greater radius than 1400ft. For lesser curves the formula—as did Pambour's—involved the square of the velocity. Hence the calculated cant could be made to counteract the centrifugal force corresponding to only one speed. Rankine's formula divided the cant into two parts, one to resist the centrifugal force, and the other to overcome the tendency of the wheels to leave the rails by virtue of the fact that although they were compelled to revolve at the same speed they had to traverse different distances in the same time while rounding a curve. Pambour's formula involved the degree of coning of the tires, but as the practice of coning the tires had become almost extinct and as in any event any taper on the tires as they left the lathe was soon lost in service the formula was inapplicable. As regarded the Gunnersbury derailment the situation therefore was that one formula required no cant at all to be given to the rails, another was inapplicable, and the third, as we showed, prescribed a cant which increased the normal or frictional resistance to sideways movement of the wheels only by an insignificant amount. The truth was that superelevation was given to an outer rail not to prevent the carriages from being overturned, but simply to keep the outer flange from rubbing hard and possibly mounting the rail. Actually the extent to which superelevation augmented the sideways resistance produced by the normal adhesion of the wheels was trifling. It did not and could not prevent the grinding of the flanges against the outer rail.

High-Pressure Water Main in America

IN consequence of the increasing demands for water, which exceeds the amount available from its Grand River supply, the city of Grand Rapids is building a pipe line 30 miles long to bring in a new supply from Lake Michigan. From a timber intake structure submerged in the lake about 1½ miles from shore there will be a steel intake pipe to the pumping station on shore, and then 30 miles of reinforced pipe to the city filter plant. About half-way along this pipe line is a second pumping station. There will be two city reservoirs of 16 million and 8 million gallons capacity. The system is designed for a daily pumpage of 55 million gallons for a population of 250,000. The 54in. intake pipe is of steel with bitumen coating inside and outside. Special joints to prevent the entrance of sand and water, and yet allow for expansion movements and storm disturbances, consist of a bolted arrangement using stainless steel bolts and lead washers ⅛in. thick. Joints have been tested to 300 lb. pressure, and each joint as made is tested to 70 lb. pressure. To reduce the total head a 4ft. tunnel five miles long was suggested, but the estimate was so high that open cutting was adopted for the entire length. The pipe is of concrete, 4ft. in diameter, with steel shell and steel reinforcing bars. The pumping station at the lake end will have five vertical-shaft centrifugal pumps of 14 to 30 million gallons daily capacity, while the intermediate station will have four horizontal shaft centrifugal pumps of similar capacities, all working under heads of 220 to 325ft. and having guaranteed overall efficiencies of 84 to 87 per cent. When this new supply system is put into operation this summer, the old intake works on the Grand River will be maintained in good operating condition for emergency use.

Scientific Instruments and Apparatus

No. III

(*Continued from page 322, April 5th*)

WESTINGHOUSE BRAKE AND SIGNAL COMPANY, LTD.

AT last year's Physical Society's Exhibition, the Westinghouse Brake and Signal Company, Ltd., exhibited for the first time a new system of obtaining a constant output from a rectifier irrespective of load and mains voltage. The registered name applied to the system is "Noregg," whilst a modification of the idea involving a floating battery is named "Westat." Technical particulars of the schemes will be found in our issue of January 20th, 1939. During the last twelve months considerable commercial developments have been made in this new potential regulating system which makes use of phase conversion to provide a three-phase full wave rectifier output on full load from a single-phase supply. Standardised sizes of the equipments have been produced in a geometric progression from 15 watts to 600 watts.

The static-phase converter, for single to three-phase, shown in principle at the last exhibition, has been completed commercially, and experience has been obtained of its performance in operating lifts, three-phase floating battery rectifiers for telephone exchanges and three-phase cinema arc rectifiers, all from single-phase supplies. Experience has shown that an efficiency of 95 per cent. is easily obtained, and that the converter can be made to operate satisfactorily as an auto-transformer as well as a phase converter. If desired, a 200 volt single-phase supply can be converted to a 400 volt three-phase supply, and even in this case efficiencies in the neighbourhood of 93 per cent. have been obtained. Commercial examples of these equipments would have been shown at the exhibition if it had been held this year. In addition there would have been demonstrated some new applications of rectifiers, of which two in particular are of special interest to engineers.

The first concerns magnetic vibrators as used in connection with shaking tables, vibrating screens, and vibrating feeders. In the past they have been

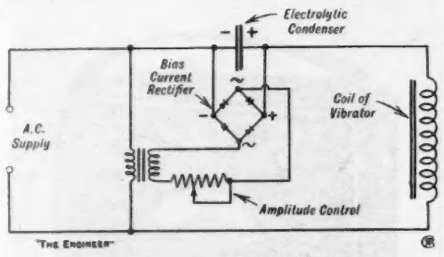


FIG. 28—MAGNETIC VIBRATOR CONNECTIONS

operated by means of a half-wave rectifier connected in series with the vibrator coil. When regulation of the amplitude of vibration has been required, it has been obtained either by a resistance, also connected in series with the vibrator coil, or by means of an auto-transformer regulating the voltage applied to the whole system. But although this arrangement is successful it is cumbersome as regards the size of rectifier and regulator because they must necessarily carry the whole of the current needed by the vibrator coil. During the past year, however, a completely new system has been developed and patented in which the rectifier and the regulating equipment have to be of sufficient size to provide only the D.C. resistance loss component of the coil current and do not have to carry the A.C. component of the coil current.

In Fig. 28 the basic principle of the apparatus is shown; the diagram shows that the A.C. component is directly applied to the vibrator coil through a condenser, which, as it happens to be polarised by a rectifier, can conveniently be a low voltage electrolytic condenser of sufficient size to carry the A.C. required to magnetise the coil with negligible voltage drop. To bias the core so that the flux pulsates with one polarity only and reaches a value having twice the peak magnitude of the normal A.C. flux, a D.C. of similar order to the A.C. is superimposed by means of the small rectifier shown connected across the condenser.

As the voltage to be overcome by this rectifier is only that resulting from the resistance of the vibrator coil winding, the voltage output required from the rectifier is but a few per cent. of the A.C. voltage applied to the coil. It will be seen that, although the current is the same, the A.C. voltage is that required to overcome the inductance of the coil, while the direct current voltage from the rectifier is only that needed to overcome its resistance. In a well-designed vibrator the ratio of these two voltages will be very large. In addition to the reduction in the size of rectifier, a similar reduction in the size of the regulating resistance is also secured, as this can conveniently be made to control the small D.C. bias power instead of having to control the large alternating VA as in the older circuit. By these means the vibrator can be made to operate exactly as if it were worked by the half wave rectifier circuit and the small resistance in the circuit can control the peak magnitude of the flux in such a

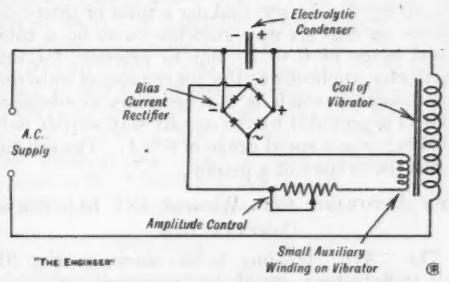


FIG. 29—MODIFIED VIBRATOR CONNECTIONS

way as to produce exactly the same result over a large range of operation as in the older circuit. Moreover, in addition to making the flux unidirectional and having a magnitude of twice the peak magnitude of the original A.C. flux, it also pulsates at a frequency of only 50 cycles per second, exactly as it would do with the half-wave circuit.

In the arrangement, Fig. 28, an auxiliary transformer is used to excite the low voltage rectifier, but in developing the arrangement it was soon seen that this was unnecessary, and that by providing a suitable secondary winding on the vibrator itself the rectifier excitation could be obtained directly from this coil without the necessity for the auxiliary transformer. The final arrangement which has been found to result in a considerable saving in cost as compared with the old established arrangements is shown in Fig. 29.

The other demonstration of the Westinghouse Brake and Signal Company, Ltd., was to have illus-

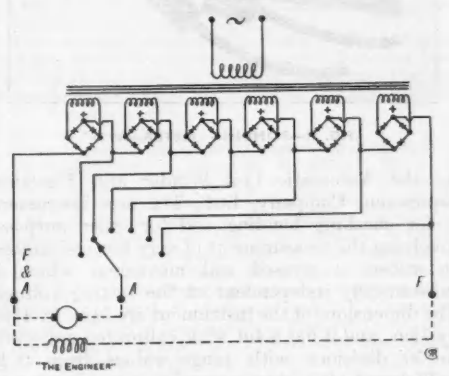


FIG. 30—SPEED CONTROL WITH RECTIFIER

trated a principle which has already found valuable application to wide range variable speed D.C. motors such as those used on the work head of cylindrical grinders. In the past, such machines have been operated from a Ward-Leonard set built into the base of the grinder. Completely satisfactory working has not, it is said, been provided, as, in consequence of the machines being of small size, their regulation is large, which has the effect of causing a wide speed variation of the motor with load, particularly when used at the lower end of its speed range.

The rectifier arrangement shown in Fig. 30 has

been developed as a static device for obtaining a similar wide range of armature voltages to provide such a wide speed range on a D.C. shunt wound motor. By tapping the individual rectifier bridges according to the speed required, the arrangement gives the same percentage regulation on all the speed steps, and consequently provides equal constancy of speed with load on any of the steps. The arrangement provides an extra flexibility in that the lower speed steps of the rectifier can be made of higher current-carrying capacity than the higher speed steps in order to enable the motor to have a heavier torque-carrying capacity at these lower speeds, as is often needed in the case under consideration.

The rectifier bridge assemblies and their associated transformer can be built together and assembled in any convenient position on the machine whilst the speed regulator, which is a simple tapping switch having six or more ways, is mounted on the control apron of the machine. If desired, the main speed steps can be sub-divided by a further switch giving fine adjustment. Any one of the positions of the fine adjustments of the switch can be used with any of the coarse steps, and in this way a very fine adjustment of the speed can be obtained over the whole of the required range. In the example shown, in Fig. 30, six steps are provided, generally of equal speed increments, and each of these steps can, if required, be sub-divided by six, making a total of thirty-six speeds on two six-way switches covering a total speed range of 6 to 1. But in practice, for this particular application, the refinement of this fine speed control switch is not necessary as adequate control is provided by the one six-way switch only working over a speed range of 6 to 1. The scheme forms the subject of a patent.

The Automatic Coil Winder and Electrical Company, Ltd.

The "Avo" bonding meter, shown in Fig. 31, was to have been one of the instruments exhibited

FIG. 31—BONDING METER—AVO

by the Automatic Coil Winder and Electrical Equipment Company, Ltd., The new instrument is for checking bonding and for other purposes involving the measurement of very low resistances. It utilises a crossed coil movement which is substantially independent of the testing voltage. The dimensions of the instrument are 5¼in. by 4⅝in. by 7⅜in., and it has a 4in. scale calibrated uniformly in 50 divisions with range values from 0–10 milliohms to 0–1 ohm., according to requirements. A 10 ampere-hour nickel-iron accumulator at the rear of the instrument provides the testing voltage. Standard leads which plug into the meter are 3ft. long and testing handles with spikes are fitted at their outer ends. Excluding the leads the meter weighs 5¼ lb.

A similar instrument is the "Avo" milliohmmeter, Fig. 32, which is a double-range instrument with a change-over switch, giving a choice of range. The lowest range is from 0 to 1 milliohm. A two-volt accumulator is required for operating the instrument, which measures 5¼in. by 4⅝in. by 4in. The weight is 3 lb.

The "Avo" test bridge, Fig. 33, is a portable self-contained measuring bridge suitable for the direct measurement of all sizes of condensers and resistances normally met with in radio and general electrical engineering. Its simplicity of operation combined with the wide range of measurements possible are claimed to make it eminently suitable for the service engineer. The face of the front bakelite panel carries all the operating controls, and their purposes are clearly engraved on the panel which fits into an aluminium case serving the dual purpose of screening the instrument and of protecting it from dust and damage. The

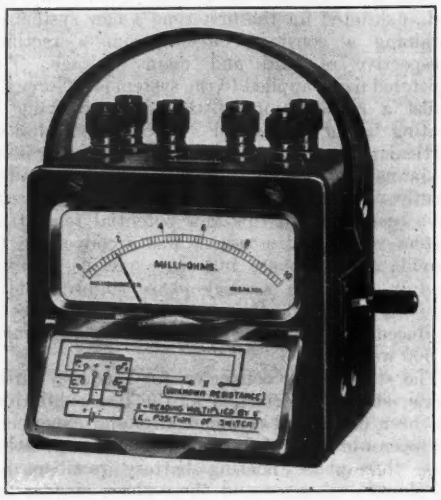


FIG. 32—MILLIOHMMETER—AVO

instrument is self-contained, the full range of capacity and resistance measurements being covered by internal standards. At the same time, a range is provided to allow measurements to be made against external standards. Moreover, the instrument can be used as a sensitive wide range value voltmeter for external measurements.

Three ranges of capacity and three ranges of resistance measurements are provided, the accurately calibrated internal resistance and condenser standards being automatically switched into circuit when the range is selected. The ranges of measurement are as follows:—Capacity range C1 from 0·000005μF to 0·005μF; range C2 from 0·0005μF to 0·5μF; range C3 from 0·05μ to 50μF.

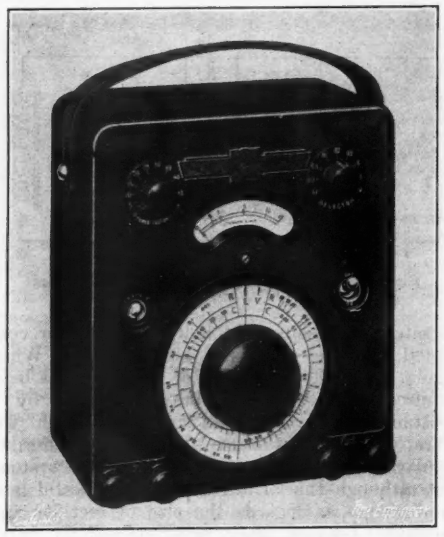


FIG. 33—TEST BRIDGE—AVO

Resistance range R1 is from 5 ohms to 5000 ohms; range 2 from 500 ohms to 500,000 ohms; range 3 from 50,000 ohms to 50 megohms.

On range 3 condenser power factor measurements may be made, the power factor being directly calibrated from 0 to 50 per cent. A special range is provided for taking measurements against external standards, the range of measurements provided being from 0·05 to 50 times the value of the external standard used. Besides its normal use for measurements of condensers and resistances, this range may be utilised for the measurement of inductances from 0·1 henry upwards, provided that the inductance to be measured has a reasonably low resistance compared with its reactance at 50 cycles.

Except at the extreme ends of the range, the accuracy of measurement is even better than 5 per cent., the logarithmic nature of the scale allowing roughly constant percentage discrimination at all values. For the two main decades of measurement, the calibrated scale is about 6in. long, giving the equivalent of 20in. of calibrated scale for the full range of either resistance or capacity measurements. Condensers of all capacities may be tested for leakage by the flashing neon method. By means of a simple switching device incorporated, a condenser which has been tested for capacity can be tested automatically for leakage without removing it from its capacity test terminals.

The simple A.C. bridge is often considered to be less satisfactory to operate than the common D.C. resistance bridge, because of the methods used to denote balance. In the D.C. bridge definite indication of balance is given by a galvanometer which can be easily and accurately read. With inexpensive A.C. bridges there are two common methods of balance—the aural method using phones or the visual method employing a cathode ray indicator, both devices being liable to give rise to inaccuracy when rapid measurements are being made. But the difficulty has been overcome in the "Avo" bridge by using an amplifier-valve voltmeter and balance is indicated by a meter on the panel of the instrument. Besides providing great sensitivity and accuracy of indication, a special circuit has been devised so that the indicator exhibits maximum sensitivity at or near balance and gets progressively less sensitive as the bridge is unbalanced. This obviates damage to the sensitive meter, as full scale deflection is only just reached even if the bridge is fully unbalanced. Near balance the sensitivity is actuallyabout twenty times the sensitivity at full unbalance.

The instrument shown in Fig. 34 is a new addition to the range of "Avo" electrical measuring instruments and takes the place of the firm's 36 range meter. Known as model 40, it differs from the latter mainly in the increased number of ranges, has a protective cut out instead of a fuse, and has three ohm ranges with internal batteries and a fourth using either A.C. or D.C. mains supplies; all have voltage adjustment. On the inside

FIG. 34—UNIVERSAL "AVOMETER"

of a moulded panel are mounted all the switching apparatus, resistances, shunts, transformer, rectifier, and the moving coil, the panel fitting into a strong aluminium case. Switching of shunts, transformer, &c. is accomplished automatically by means of two switch knobs on the panel plainly marked so that the range in use appears opposite an arrowhead. As no external apparatus is needed, only two terminals are required to connect up the instrument by means of spring clips for any test. The left-hand switch knob governs the D.C. ranges and the right-hand knob the A.C. ranges. Interlocking ensures that it is only possible to obtain D.C. readings by setting the D.C. switch to a range and rotating the A.C. switch to the position marked D.C. A similar procedure is necessary when making an A.C. measurement and the instrument is therefore protected from damage in the event of both switches being left on ranges when making a test, for in this condition there is no circuit through the meter.

Should A.C. be passed through the instrument when it is set to a correct range value of D.C., or vice versa, no pointer indication will be produced and no damage will result. Since a pointer

deflection can only be produced with the switches set for the same type of measurement, it is possible to determine whether the source of supply is A.C. or D.C. An A.C. overload will, however, if inadvertently applied to the D.C. range produce a forward indication of the pointer which serves as part of the protective system.

The automatic cut-out mentioned eliminates the inconvenience of replacing fuses. If an overload be applied to the meter, the cut-out knob springs from its normal position in the panel, thus breaking the circuit, and on being depressed the instrument is ready for use again. If owing to overload the acceleration of the moving coil is excessive the mechanism operates. It may even release the cut out before the pointer has traversed one-third of the scale length and a reverse overload of somewhat higher value may also operate the mechanism, but careless use must be avoided. The cut-out gives almost complete protection to the entire meter and only fails in the very worst cases, as, for instance, if the mains are connected across the meter when it is set for a current range.

The movement consists of an aluminium former, wound with copper wire supplemented with constantan wire to reduce any possible error. The coil is pivoted on hardened and highly polished steel points between conical sapphire jewels and swings in the gap of a powerful well-aged cobalt steel magnet. For the purpose of conveying current to the moving coil there are two phosphor-bronze hair springs which also serve to return the pointer to zero. With the special pointer provided very fine readings can be taken. Moreover, the complete movement is perfectly balanced and properly damped so that the pointer comes quickly to rest.

The scale-plate has three sets of markings each approximately 5in. long. The top one is for resistance measurements and is marked 0–1000, whilst the middle scale is for current and voltage measurements both A.C. and D.C. and is marked 0–120 with divisions of approximately 1 mm. The third scale is calibrated 0–480 volts in major steps of 50 volts, sub-divided into divisions of 5 volts each. This scale is only used in conjunction with the 480 volt ranges marked on the switch knobs. Each scale is individually calibrated and hand-marked to agree with the readings of standard instruments, and the plate has an untarnishable mirror to prevent parallax errors. The instrument has a total resistance of 200,000 ohms and is equipped with a press button which doubles the sensitivity without affecting its resistance.

With one exception, each successive range, as indicated by the switch knob, is ten times the previous one, thus avoiding the use of awkward multiplying constants and possible errors. The exception is, of course, the 480 A.C. and D.C. range which, with its associated 240-range press button, may be employed for extremely accurate measurements of mains voltage. By pressing the button, which incidentally is only intended for use when measuring current and voltage, the normal full-scale deflection as shown by the switch knob is halved and consequently twice the normal length of pointer deflection is produced with a given input, the meter resistance being unchanged. In cases where only a small pointer deflection is produced on normal ranges, it is obviously of great service in obtaining more easily read indications.

On D.C. and A.C. from 25 to 100 cycles, the meter is guaranteed accurate to first grade B.S. limits. The great width of measurements covered by the instrument can be gauged by the D.C. voltage ranges where the ratio of the largest to the smallest calibrated indication is approximately two million to one. Owing to the accuracy of calibration and the care taken in the manufacture of the various parts, the limits of error laid down for the first grade instruments are not even approached. Although first grade limits are not claimed above 100 cycles, the meter is reasonably accurate up to 10,000 cycles and audio-frequency voltages and currents can be measured quite successfully.

To measure current, the instrument is set to a suitable range and connected in series with the apparatus being tested. If it be desired to extend the D.C. current ranges beyond the normal limits of the meter, the 120 millivolt range can be used with external shunts. Similarly the extension of A.C. current ranges may be accomplished by using a current transformer to suit the 120 ma. A.C. range.

When measuring voltage it is merely necessary to set the instrument to the appropriate range and connect the leads across the source of voltage to be measured. On every normal range except the 12 volt A.C. range, the instrument consumes 6 ma. for full scale deflection and proportionally less for smaller deflections. When using the press button, the current consumed for any deflection is halved, the resistance being unaffected. In the case of the 12 volt A.C. range full scale deflection entails 60 ma. and 30 ma. in the two cases.

When used as an ohmmeter a 1·5 volt cell in the instrument supplies the current for making the test on the two lower ranges. To make any resistance tests on either of these ranges it is only necessary, after adjustment, to connect the leads across the article under test, and its resistance will be indicated on the top scale.

The 100,000 ohm range involves the use of two 4·5 volt batteries which together with the 1·5 volt cell are housed in the battery compartment at the top of the instrument. When the instrument is set, resistance measurements can be made by connecting the leads across the article and the actual readings on this range should be multiplied by 100. A 1 megohm resistance range is available with the aid of the A.C. or D.C. mains or other source of voltage used in conjunction with the 120 volt ranges. The ranges and other data are tabulated above.

D.C. current		D.C. voltage		A.C. current		A.C. voltage	
Range	Value per division	Range	Value per division	Range	Value per division	Range	Value per division
0– 6 mA	50 μA	0– 60 mV	0·5 mV	0– 6 mA	50 μA	0– 6 volts	50 mV
0– 12 mA	100 μA	0–120 mV	1 mV.	0– 12 mA	100 μA	0– 12 volts	100 mV
0– 60 mA	500 μA	0–600 mV	5 mV	0– 60 mA	500 μA	0– 60 volts	500 mV
0–120 mA	1 mA	0– 1·2 volts	10 mV	0–120 mA	1 mA	0–120 volts	1 volt
0–600 mA	5 mA	0– 6 volts	50 mV	0–600 mA	5 mA	0–240 volts	2 volts
0– 1·2 amps.	10 mA	0– 12 volts	100 mV	0–1·2 amps.	10 mA	0–480 volts	5 volts
0– 6 amps.	50 mA	0– 60 volts	500 mV	0– 6 amps.	50 mA	0–600 volts	5 volts
0– 12 amps.	100 mA	0–120 volts	1 volt	0–12 amps.	100 mA	0–1200 volts	10 volts
		0–240 volts	2 volts				
		0–480 volts	5 volts				
		0–600 volts	5 volts				
		0–1200 volts	10 volts				

RESISTANCE

Range	First indication		Indication multiplier
0– 1000 ohms	0·1 ohm	Using internal 1·5 volt cell	1
0– 10,000 ohms	1·0 ohms	Using internal 1·5 volt cell	10
0–100,000 ohms	10·0 ohms	Using internal 9 volt battery	100
0–1 Megohm	100·0 ohms	Using external source of voltage A.C. or D C	1000

SANGAMO WESTON, LTD.

The current transformer, Fig. 35 (Model S1) was to have been shown at the Physical Society's Exhibition by Sangamo Weston, Ltd. These instrument transformers have been designed to cover a wide range of accuracies specified by the B.S.I. for the most modern metering current transformers. The windings are toroidally wound on ring cores of high-permeability low-loss nickel-iron alloy. The coils are enclosed in a strong moisture proof housing of "all-insulated" moulded bakelite which eliminates the need for earthings. A combination terminal block and automatic short circuiting device are provided, the latter enabling the secondary leads to be disconnected from the secondary terminals with complete safety while the transformer is on load. In accordance with B.S.I. regulations, the primary and secondary terminals are marked to indicate their respective polarities. The transformers are small, light, and have a neat appearance. At all stages of manufacture they are subjected to rigid tests and conform with B.S.S. No. 81–1936.

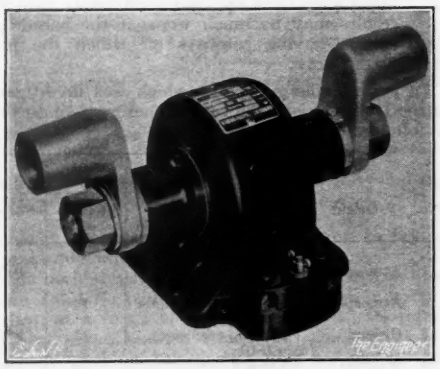


FIG. 35—CURRENT TRANSFORMER—SANGAMO WESTON

In the illustration, Fig. 35, the combination terminal block and automatic short circuiting device can be seen at the base of the transformer. It is an integral part of the bakelite moulding and contains the secondary output terminals and also clips which are separated by a bakelite projection in the inside of the terminal cover. When the cover is not in position, the clips short circuit the transformer secondary leads and the cover can only be attached in the position which opens the clips and removes the short circuit. Model S1. transformers are insulated for 6600 volt L systems and have single-turn primaries with open primary terminals. The primary ratings are 300, 400, 500, 600, 800, 1000, and 1500 amperes and the secondary rating 5 amperes. The rated output is 5, 15, or 30 VA, the latter not being available either with 300 or 400 amperes primary. The accuracy is B.S.I. class AM, BM, or CM, but not class AM with a 300 ampere primary.

A current transformer designated model S2 is made in two forms, 1 and 2, both insulated for 700 or 6600 volt systems. The primary ratings in the former case are 5, 10, 15, 20, 30, 40, 50, 60, 75, 100, 150, 200, or 300 amperes, and in the latter case 400, 500, 680, or 800 amperes. The secondary rating is 5 amperes in both cases and the rated output 5, 15, or 30 VA, also in both cases. The accuracy for each of these current transformers is B.S.I. class AM, BM, or CM.

(To be continued)

The Iron and Steel Institute

THE annual meeting of the Iron and Steel Institute will take place at the offices of the Institute, 4, Grosvenor Gardens, London, S.W.1, on Thursday and Friday, May 2nd and 3rd, 1940, commencing each day at 10 a.m. Non-members of the Institute will be welcome at the meeting, but in order to meet the wishes of the Press and Censorship Bureau it will be necessary for them to bring with them a letter of introduction signed by a member of the Institute. Both members and non-members will be requested to sign a declaration on entering the meeting room that they will treat the proceedings as strictly confidential.

The programme of proceedings is as follows :—

Thursday, May 2nd.—10 a.m.—Presentation of annual report and statement of accounts for 1939.

Election of new members and associates.

Induction of the newly-elected President, Mr. John Craig, C.B.E., into the chair.

Announcement of the election of Monsieur Eugène Schneider, D.Sc., to Honorary Membership.

Presentation of the Bessemer Gold Medal for 1940 to Dr. Andrew McCance.

Presentation of the Williams Prize for 1939 jointly to Mr. W. B. Lawrie, for his paper on "The Refining of Metal in the Basic Open-Hearth Furnace : the Influence of Fluorspar on the Process," and Mr. W. T. Wilson, for his paper on "The Rolling of Sections at the Appleby-Frodingham Steel Company, Ltd."

Announcement concerning the award of the Andrew Carnegie Medal for 1939 and the Ablett Prize for 1940. The Council has decided to award an Andrew Carnegie Silver Medal for 1939 to Mr. Bo W. L. Ljunggren for his report mentioned below.

Presidential address.

Presentation of the following papers for discussion :—"Researches into the Structure of Alloys," by A. J. Bradley, F.R.S., W. L. Bragg, F.R.S., and C. Sykes. "Manufacture of Pig Iron in America," by Wm. A. Haven.

2.30 p.m.—Presentation of the following papers for discussion :—"Report on Corrosion Research Work at Cambridge University Interrupted by the Outbreak of War," by U. R. Evans. (Paper No. 1/1940 of the Corrosion Committee). "The Damping Capacity of Steel and Its Measurement," by G. P. Contractor and F. C. Thompson. (Paper No. 1/1940 of the Alloy Steels Research Committee). "The Estimation of Hydrogen in Steel and other Metals," by W. C. Newell. (Paper No. 1/1940 of the Oxygen Sub-Committee of the Heterogeneity of Steel Ingots Committee).

Friday, May 3rd.—10 a.m.: Presentation of the following papers for discussion :—"Anti-Piping Compounds and their Influence on Major Segregation in Steel Ingots," by E. Gregory. (Paper No. 1/1940 of the Committee on the Heterogeneity of Steel Ingots.) "Heat Transfer in the Flow of Gas through the Interstices of a Bed of Solid Particles," by O. A. Saunders and H. Ford. "Method of Sclero-Grating Employed for the Study of Grain Boundaries and of Nitrided Cases : Grain Structures Revealed by Cutting," by Bo W. L. Ljunggren. (Andrew Carnegie Research Report).

The Council has decided that, in the present circumstances, the annual dinner of the Institute shall not be held this year. Instead, a members' luncheon will be held at Grosvenor House, Park Lane, London, W.1, on Friday, May 3rd, 1940, at 1 p.m.

Refuelling in Flight

By MARCUS LANGLEY, M.I.Ae.E., M.I.Ae.S., A.M.I.N.A.*

IN an earlier report† a comparison between normal and refuelled aircraft was worked out. The basis used was that of equal take-off loading, and very remarkable increases in range and earning capacity were shown to be possible with refuelling in flight.

A criticism has been made that this report paid insufficient attention to the landing speed and the service ceiling. If two similar aircraft, one normal and one refuelled, took off at the same wing loading, says the critic, the normal one would have a much lower landing loading at the end of its journey, with consequent lower landing speed. The refuelled one, having taken off at the same loading, would have its weight considerably increased by the process of refuelling immediately after the take-off and would therefore have a lower service ceiling throughout the flight. At the end of the journey, with all the fuel and oil consumed, it would have come back to almost the same loading at which it took off and its landing speed would therefore be considerably higher than that of the normal machine.

A prominent official in one of the leading air transport companies has expressed the opinion that the limiting loading for landing should be about 30 lb. per square foot, but that this view may be modified by further developments in wing sections, flaps, and undercarriages. On the subject of ceiling, he thought that an aircraft having engines supercharged to 5000ft. should still be able to operate on its cruising power, with full load on board, at 15,000ft. Admittedly, these are expressions of opinion, but

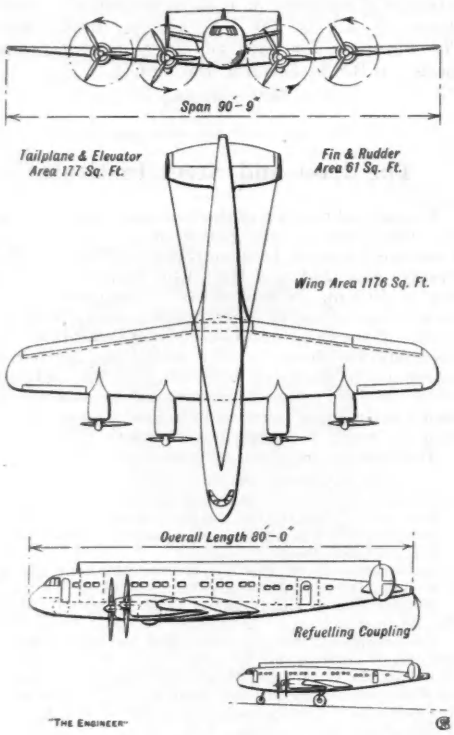

Span 90'-9"
Tailplane & Elevator Area 177 Sq. Ft.
Fin & Rudder Area 61 Sq. Ft.
Wing Area 1176 Sq. Ft.
Overall Length 80'-0"
Refuelling Coupling
"The Engineer"

Fig. 1—*Typical Airliner for Refuelling in Flight*

whilst some may disagree with the actual figures quoted, they do represent an order of things which is desirable in actual air transport operations.

An investigation has accordingly been made into this problem to find if it is indeed a serious criticism of the assisted take-off, whether by catapults, composite aircraft, or refuelling. The answer is that for long range aircraft, designed to carry a reasonable pay load one must either assist the take-off and the initial rate of climb, or else go outside the existing I.C.A.N. regulations governing take-off distance. One must also accept the dangers arising from a very flat angle of climb (perhaps less than 5 deg.). In the transition stage around the actual "unstick," the aircraft has to accelerate from its stalling speed up to its best climbing speed with full load on board, this load including all the fuel. The difficulty of maintaining adequate stability and the dangers arising from a possible engine failure during its transition period make the manœuvre an extremely hazardous one, to which passengers and mails should not be lightly subjected.

Most pilots, and most operating companies, too, with the interest of safety at heart, would prefer to take-off light with a short run, to climb away from the ground at a much better angle, and then to refuel at a reasonable height and speed, when the aircraft is on its course. The refuelling operation means very little to the pilot of the receiving machine. He cannot feel it on his controls, and he is usually only aware of it through the signals he receives from the operators. On several occasions the receiving aircraft has been under the control of the automatic pilot whilst being refuelled.

Safety in Take-Off

A very thorough investigation into the safety of the take-off of aeroplanes was instigated by the Dutch Government in 1938, and a long report published.‡ This report opens with a comment on the number of serious accidents which have occurred in the process of taking-off and explains that in the transition from the run on the ground to actual flight in the air the aeroplane passes through a region of low flight speed. It is in this transition region that the margin of safety is small owing to the risk of stalling and the still highly imperfect controllability. In the region of low speeds the disturbing influence of a combination of secondary factors may become very serious, and the pilot in an effort to overcome the effects of them may stall. Amongst these secondary factors might be mentioned :—

(*a*) Disturbed air movements, particularly if these include downward velocities. Also included in the atmospheric influences are temperature and pressure.

(*b*) Height of the aerodrome above sea level. This is equivalent to a drop in density affecting both the lift and the engine output.

(*c*) Engine influences, not only as affected by the atmospheric conditions resulting in a possible loss in power, but also by the hazard of an engine failure during the take-off.

(*d*) Aerodrome surface conditions in the form of sloping ground or in an abnormally high co-efficient of friction due to long grass or mud.

(*e*) Material defects in the aircraft such as the binding of a wheel brake, inadequate ignition in the engine, a defect in the airscrew adjustment, or a fault in one of the important instruments.

(*f*) Errors in handling. This includes taking off when not dead into wind (an effect which may be influenced by a veering wind), an incorrect angle of incidence, bad steering, particularly at high take-off speed, and incorrect loading of the aircraft. The probability of pilotage errors is much greater when taking-off blind, and the results may be much worse if the aerodrome is one having runways off which the pilot might stray.

In a particular aeroplane which was investigated in the Dutch report, the various factors were asesssed as follows :—

No.	Origin	Condition	Increase in length of take-off	Factor
			per cent.	
1	Atmosphere	Air temperature 44 deg. Cent.	18	1·18
2	Atmosphere	Height of barometer 722 mm.	13	1·13
3	Ground	Friction coefficient 0·10	12	1·12
4	Material	Various	10	1·10
5	Personnel	Various	10	1·10

It is extremely unlikely that all these adverse factors would occur at the same time, but if the worst three coincided the effect might be found by multiplying the factors.

The product of the three largest factors is :

$$1{\cdot}18 \times 1{\cdot}13 \times 1{\cdot}12 = 1{\cdot}49$$

Thus for the particular aeroplane under consideration, the possible length of take-off may be 50 per cent. greater than that estimated under standard atmosphere conditions for a perfect aerodrome.

It is pointed out in the Dutch report that a temperature of 44 deg. Cent. does not occur in the Netherlands, but it certainly does in the tropics. A 5 per cent. drop in atmospheric pressure is quite frequent in Europe. The drop in density on a high altitude aerodrome is included under this heading.

The frictional coefficient of an aerodrome having a good runway of hard turf with short grass is about 0·05. When there is long grass or mud, however, this coefficient may be more than doubled, and although the aerodrome of the future will be well surfaced, it is possible that an aeroplane might leave its runway in a blind take-off. In these conditions it is very doubtful whether a safe take-off could be made. Even if the aircraft does leave the ground successfully it has covered a very considerable distance and the 1080 yards which is quoted under Fig. 7 for an aeroplane taking off at 50 lb. per square foot might frequently in actual service stretch to as much as 1500 yards.

Certain of these adverse factors, particularly those associated with atmospheric conditions, would have a corresponding effect on the initial rate of climb. We might then find the aircraft at full power, climbing at an angle of only 3 or 4 deg. Although large aerodromes, with even larger sterilised areas around them, may be easy to provide in parts of Australia and Africa, the problem becomes acute in more densely populated territory. Of course, a route operated by a heavily loaded machine (without assistance in the take-off) would need such aerodromes at all stopping places. In the South of England it would be almost impossible to provide an adequate space clear of

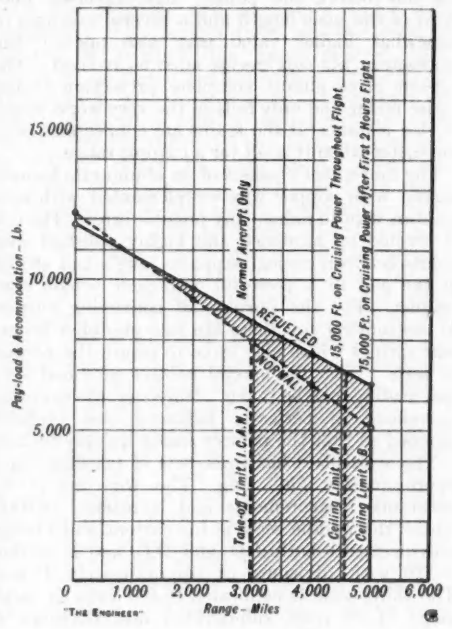


Fig. 2—*Comparison of Normal and Refuelled Aircraft designed to Land at 30 lb. per square foot Wing Loading*

factory buildings, steeples, or hills, at any reasonable cost. Already suitable land is costing as much as £500 per acre, although £100 per acre is more usual. By the time the surface and buildings are completed, the capital cost is such as to put an enormous premium on the normal take-off. An initial cost of £2,000,000 may be low for the completed aerodrome with concrete runways, adequate hangar accommodation, workshops, offices, and passenger handling facilities. The New York City Municipal Airport at North Beach, Long Island, is said to have cost $40,000,000 already, and it is estimated that at least another $5,000,000 will be required to complete it.

Short take-off followed by refuelling is, therefore, not only desirable in the interests of safety, but has in its favour a very strong economic argument. The cost of operating a refuelling base is relatively

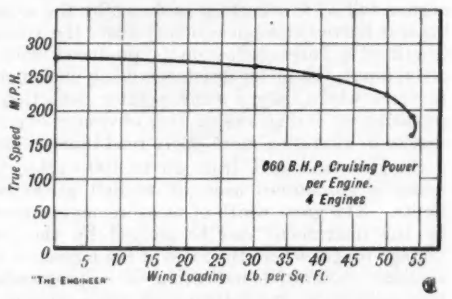


Fig. 3—*Cruising Speed on Maximum Economic Cruising Power at 15,000ft.*

minor and does not appear as a capital expense in the balance sheet of civil air transport. Such a base is flexible and mobile, and lacks the disadvantage of frozen capital as represented by over-sized aerodromes with prepared runways, catapults, and so forth. Admittedly, tankers must be maintained, but then so must aerodromes. Tanker maintenance cost is only a fraction of that of the additional area needed if refuelling is not used.

Assumptions in the Investigation

A hypothetical aeroplane has been chosen as an example for the present investigation, and its performance and pay-load compared for ranges of 2000, 3000, 4000, and 5000 miles. For each range two alternatives were considered, one with a normal take-off and the other taking off with only 200 gallons of fuel on board, the remainder being added in flight. In order to eliminate from the comparison between the two any unnecessary variables, they have been assumed to have the same wing loading at landing (30 lb. per square foot), the same consumable load,

* Flight Refuelling, Ltd. Abstract from a report.

† "Report on the Effects of Large Increments in Wing and Power Loadings on the Performance of Aircraft," by Marcus Langley.

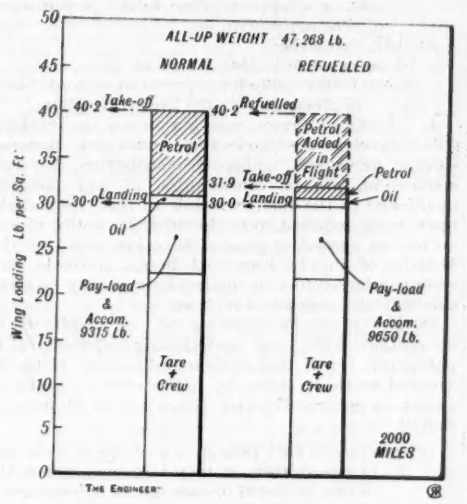
‡ "Investigations on the Safety of the Take-off of Aeroplanes in connection with the Qualities of the Aeroplane, 1938," by Ing. A. G. von Baumhauer, "Journal of the Royal Aeronautical Society," September, 1939.

cruising speed, ceiling, &c. In fact, from the moment the refuelled machine has received its load in flight the two are identical in outward form and performance.

The differences between the two lie in the following points only :—

1. The undercarriage weights are assumed to be 6 per cent. of the take-off weight in each case.
2. The refuelled machine has 250 lb. added for the appropriate equipment.
3. The take-off weight of the normal machine is its full flying weight, whilst the take-off weight of the refuelled one is the same less the weight of all but 200 gallons of fuel.
4. The take-off distances, and the initial climbs are appropriate to the respective take-off weights.

The hypothetical aeroplane used in this example

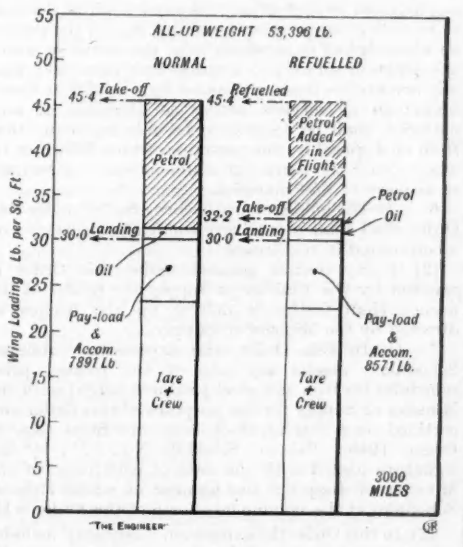


	Normal	Refuelled
Cruising speed, average at 5000ft. on 800 B.H.P. per engine	256 m.p.h.	
Initial rate of climb	2150ft. per min.	2920ft. per min.
Initial angle of climb	1 in 6·48 / 8 deg. 48 mins.	1 in 4·69 / 12 deg.
Take-off run, to clear 66ft. barrier	525 yards	330 yards

Fig. 4—*Aircraft designed for 2000 Miles Range ; All-up Weight 47,268 lb.*

is a low wing, four-engined monoplane of clean design. It is equipped with Hercules IVc engines, driving D.H. Hydromatic airscrews. The main planes carry Handley Page slotted flaps, ailerons, and wing tip slots.

This machine was fully described and illustrated



	Normal	Refuelled
Cruising speed average at 5000ft. on 800 B.H.P. per engine	254 m.p.h.	
Initial rate of climb	1800ft. per min.	2880ft. per min.
Initial angle of climb	1 in 7·94 / 7 deg. 12 mins.	1 in 4·76 / 11 deg. 50 mins.
Take-off run, to clear 66ft. barrier	680 yards	340 yards

Fig. 5—*Aircraft designed for 3000 Miles Range ; All-up Weight 53,396 lb.*

in the previous report, but its general arrangement is given in Fig. 1. All the aerodynamic characteristics, the performance, and the methods of estimating the tare weight, disposable load, and fuel consumption are as given in that report.

Had a different aeroplane been chosen for the example the quantitative result might have been rather different, but only to a limited extent, since the hypothetical machine is of the same general type as most modern air transports and heavy bombers (*e.g.*, Short 14/38, Fairey 15/38, Boeing 307 Stratoliner, Boeing XB-15 Bomber, &c.).

Calculations

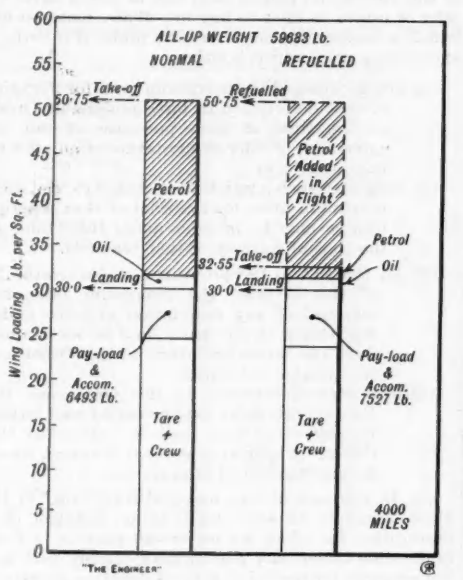
Separate estimates have been made for ranges of 2000, 3000, 4000, and 5000 miles, the aircraft in each case being assumed designed for the range considered. The normal and refuelled aircraft for each range are compared graphically in Figs. 2, 4, 5, 6, and 7.

Results of Investigation

Limit of Take-off.—The final summary of the investigation is given in Fig. 2, in which the weight of "Pay Load plus Accommodation" is plotted against Range for both the normal and refuelled aircraft.

In this particular comparison, all other possible variables being eliminated, the differences in payload are due only to the different weights of the undercarriage (an appreciable amount), and the weight of the refuelling gear.

At 2000 miles range the refuelled machine has a



	Normal	Refuelled
Cruising speed average at 5000ft. on 800 B.H.P. per engine	251·5 m.p.h.	
Initial rate of climb	1520ft. per min.	2840ft. per min.
Initial angle of climb	1 in 9·44 / 6 deg. 3 mins.	1 in 4·84 / 11 deg. 42 mins.
Take-off run, to clear 66ft. barrier	860 yards	350 yards

Fig. 6—*Aircraft designed for 4000 Miles Range ; All-up Weight 59,683 lb.*

pay load 3½ per cent. better, but this grows to 27½ per cent. at 5000 miles range.§

The normal aeroplane, however, reaches the limit of an I.C.A.N. take-off (656 yards to clear a 66ft. barrier) at a range of about 3000 miles. Its initial angle of climb is then 7 deg. 17 min., whilst the refuelled machine, taking off light, has cleared the barrier in 340 yards and is climbing at an angle of 11 deg.

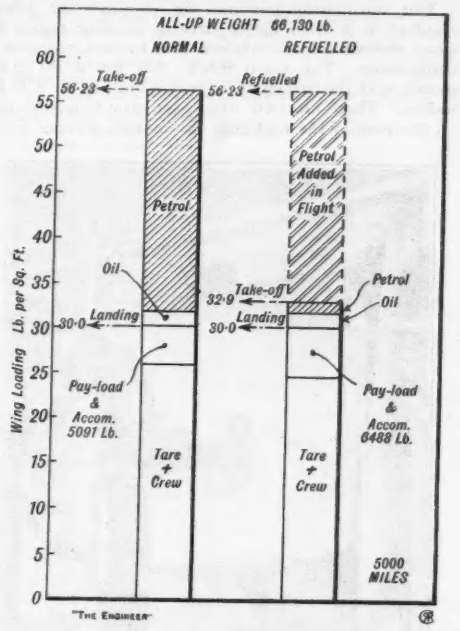
The normal aeroplane can only work above that range if one of two alternative sacrifices is made. It must either cut its pay load, pound for pound with the additional fuel required, or it must break away from the I.C.A.N. requirements for take-off. If the second alternative were chosen then for 4000 miles range it would need 860 yards to take off whilst the refuelling machine was still only taking 350 yards.

At 5000 miles the position is much worse and the take-off distances are 1080 yards and 360 yards respectively. The corresponding initial angles of climb are 5 deg. and 11½ deg.

Limit of Ceiling.—The large fuel load needed for these long ranges, however, begins to impose the limit of ceiling and as suggested at the beginning of this report the aircraft should be able to operate on normal cruising power at 15,000ft. so as to clear icing and other bad weather conditions near the ground.

The limit is imposed equally on both normal and refuelled aircraft, since they are identical in form and loading, once they have full tanks.

As the load is increased the angle of incidence for a given power must also increase and with it the induced drag. The cruising speed, therefore, drops off slowly at first until at some high loading it dives steeply to zero. For this example we have calculated the cruising speed at 15,000ft., which would be available on an engine output of 660 B.H.P. per engine. This is the power at maximum economic cruising revs. for the Hercules IVc engine, which is normally supercharged to give maximum economic cruising power at 5000ft. It will be seen from Fig. 3 that the cruising speed drops off from 265 m.p.h. at 30 lb. per square foot wing loading to 223 m.p.h. at 50 lb. Thereafter it falls steeply and it would appear that the service ceiling on this power is reached at slightly over 54 lb. per square foot. The ceiling condition, therefore, becomes operative at a point between 4000 and 5000 miles range if it is to be imposed over the whole flight of the aircraft. This ceiling condition corresponds to the fully loaded aircraft and will actually improve as the flight progresses, due to the burning



	Normal	Refuelled
Cruising speed, average at 5000ft. on 800 B.H.P. per engine	249 m.p.h.	
Initial rate of climb	1250ft. per min.	2800ft. per min.
Initial angle of climb	1 in 11·47 / 5 deg.	1 in 4·91 / 11 deg. 30 mins.
Take-off run, to clear 66ft. barrier	1080 yards	360 yards

Fig. 7—*Aircraft designed for 5000 Miles Range ; All-up Weight 66,130 lb.*

up of the consumable load. If, therefore, it were felt that a slightly lower standard might be allowed in the first two hours of flight, we may put the ceiling limit at 5000 miles range.

§ The difference in an actual aeroplane might well be greater than this, since the 6 per cent. of the take-off weight assumed for under-carriage is possibly conservative, particularly for a tricycle undercarriage.

Electrical Equipment of the Derby Baths, Blackpool

One of the finest indoor pools in the world, the Derby Baths, has recently been completed for the Blackpool Corporation. It is a sea water pool, and the main bath, which measures 155ft. by 55ft. will accommodate 2000 bathers, while the arena seats 1760 spectators. There is also a learners' pool, twenty slipper baths with hot, fresh and sea water, turkish baths, &c.

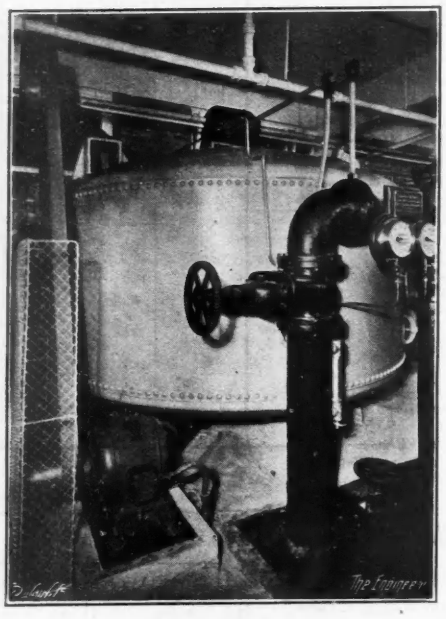
Extensive electric pumping and fan equipment is required for an installation such as this, and as it is essential that the motors should operate with a very high degree of silence, Crompton Parkinson "Super-Silent motors have been employed throughout. The pumps, motors and auxiliary plant are installed in duplicate to avoid interruption of service. The bath is supplied with sea water from a pumping station on the promenade, the water being delivered at the rate of 600 g.p.m. against a 70ft. head to a 120,000 gallon settling tank by 18 H.P. vertical spindle motor-driven pumps. The pumps are not self-priming and an injector primer is therefore fitted driven by a 1 H.P. motor. In the settling tank the water deposits impurities which are drawn off—after the main body of water has left the tank—by a sludge pump driven by a vertical spindle motor of 6 H.P.

Next the water is pumped either through filter stages to roof tanks—for showers, slipper baths, &c.—or to the main filter. The roof tank filter requires a ¼ H.P. motor for the chemical pump and a 3½ H.P. screen protected motor for the filter washing mechanical agitator. The main flow undergoes a continuous filtering process which completely changes the half-million gallons of water every three hours. The main filters are arranged in two banks of six units either of which can be taken out of service without interrupting the process. The mechanically operated agitators to wash the filters are driven from line shafts, each shaft having a 5 H.P. motor. The water thereafter passes through an aerator to freshen

it by the injection of air, the aerator unit being driven by a 2½ H.P. screen protected motor. Chlorine and ammonia treatment follows, while the water is heated before flowing into the pool. The process is continuous, water being drawn from the pool, chemically treated, strained, and then circulated. The chemical pump uses a ½ H.P. motor, while the circulating pump uses a 42 H.P. variable speed motor.

The learners' pool equipment, while on the same lines, is naturally on a smaller scale, the main pump using a 3½ H.P. variable speed motor. Sparge rails which will project a cascade of water are fitted to both pools, the main rail requiring a 10 H.P. motor for the booster pump. The rain spray is a similar fitting, the pump in this case using a 4 H.P. motor.

The automatic plenum air conditioning plant employs a 4 H.P. motor driven washing pump to clean the air intake, while a ½ H.P. motor drives a compressor. The main intake fan has a 20 H.P. motor, and the principal extractor fan has an 8 H.P. motor. There are two other extractor fans situated on the roof of the building, the motors driving them



MAIN FILTER

being totally enclosed and weatherproof. These subsidiary extractor fans deal with the outgo from the basement and boiler house. All these fan motors are of the variable speed type. In the boiler house heat is provided for sea water, fresh water, and central heating, a total of nine calorifiers being used. The motor plant consists of two 1½ H.P. sump pump motors, and one 1 H.P. one-hour-rated slag hoist motor. Motors of ¾ H.P. drive the circulating pumps for the hot sea and fresh water, and a 1 H.P. motor drives the central heating circulating pump which supplies 400 radiators.

Vacuum cleaning plant is installed and has a 10 H.P. motor for its turbine. Push button control for the electrical window opening system is provided. An electric alarm level indicator determines the operation of the sludge pump.

The power supply is taken from the Corporation mains at 346 volts three-phase 50 cycles, while the lighting on 200 volts single phase has an emergency "Keepalite" standby system. The auxiliary plant is duplicated throughout. The motors, with the exception of the vertical spindle motors, are all of the ring lubricated sleeve bearing type. The starters are fitted with three overload and no-volt releases complete with isolating switches and ammeters. Some of the plant is illustrated on page 352.

Oil-Engined Rail Traction Transmission Systems

IN our annual review article on the progress of oil-engined rail traction in 1939 we remarked that hydraulic transmission was steadily gaining ground, and that locomotives with purely mechanical transmission and friction clutches were steadily disappearing. It has been pointed out to us that whilst evidence supports that statement when applied to world conditions and to oil engined rail vehicles of different types for other and widely varying operating conditions, it does not apply to the majority of the oil engined locomotives that are being built purely for shunting work in England. For instance, John Fowler and Co. (Leeds), Ltd., Leeds, inform us that from 1929 to December 1st, 1939, every oil-engined shunting locomotive built by them—in sizes from 40 B.H.P. to 150 B.H.P.—incorporated a purely mechanical transmission and friction clutch, such as was described and illustrated in the article referred to above, and from the year 1929 to date the proportion of oil engined locomotives of their manufacture with mechanical transmission was 98·86 per cent. and with fluid coupling 1·14 per cent.

Advance in Iron and Steel Prices

THE Control of Iron and Steel (No. 8) Order, 1940, dated April 4th, 1940, has been issued by the Minister of Supply and runs as follows :—

1.—(1) No person shall acquire or agree to acquire any material mentioned in the First Schedule to this Order: except under the authority of a licence granted, or in accordance with a special or general direction issued, by the Minister of Supply.

(2) No person shall dispose of or agree to dispose of any material mentioned in the First Schedule to to this Order: except (*a*) to a person who is authorised to acquire that material by virtue of a licence granted by the Minister of Supply, or (*b*) under the authority of a licence granted by the Minister of Supply authorising that person to dispose or agree to dispose of that material to a person who is not subject to the provisions of paragraph (1) of this Article, or (*c*) in accordance with a special or general direction issued by the Minister of Supply.

2.—(1) Subject to the provisions of paragraph (4) of this Article, no person shall buy or sell or agree or offer or invite an offer to buy or sell any material for which a maximum price is in force under this Order: except at a price which is either

(*a*) not in excess of the maximum price for material of that description in force under this Order at the time of such purchase or sale or agreement or offer or invitation of an offer to buy or sell; or

(*b*) defined in such a way that it cannot exceed such maximum price for material of that description as may be in force under this Order at the time of delivery of such material.

(2) (*a*) Subject to the provisions of paragraph (3) of this Article, the maximum price for material of any description in force under this Order at any time shall be ascertained from the Second Schedule to this Order and the Related Schedules.

(*b*) The Second Schedule to this Order and the Related Schedules may be varied, and further Related Schedules may be added to this Order, by special or general direction issued by the Minister of Supply.

(3) In the case of any material mentioned in the First Schedule to this Order being material of a description for which no maximum price is in force under this Order, any person shall comply with any notice given (or special or general direction issued) by the Minister of Supply

(*a*) requiring that person not to sell or agree or offer to sell any such material at a price exceeding a maximum price to be fixed by the Minister of Supply for that material, or

(*b*) fixing the maximum price for that material.

(4) If any person shall satisfy the Minister of Supply that, by reason of transport or other difficulties, that person is not able to obtain for delivery in the United Kingdom a reasonably adequate supply of any material situate in the United Kingdom for which a maximum price is in force under this Order, or is not able to obtain such a supply of that material through the usual channels of supply—the Minister of Supply may authorise that person to buy and any other person to sell to him that material in such quantity, and at such price in excess of the maximum price for that material in force under this Order, as the Minister of Supply may, having regard to such difficulties and the public interest, deem reasonable.

(5) Notwithstanding anything contained in paragraphs (1), (3), or (4) of this Article: in any proceedings in respect of any alleged contravention of any provision of any of those paragraphs being a provision relating to the price of any material, it shall be a defence if the defendant shall prove that the price with respect to which the contravention is alleged had, before the coming into force of this Order, been paid in pursuance of a contract of sale made before the coming into force of this Order.

(6) In this Article the expressions "buy" and "sell" include any acquisition of ownership and any disposal of ownership, respectively, in pursuance of any agreement to sell whether such agreement was made before or after the coming into force of this Order.

3.—(1) Notwithstanding anything contained in Article 1 or 2 of this Order: in any proceedings in respect of any alleged contravention of any provision of any of these Articles by any acquisition, disposal, purchase, sale, or agreement, it shall be a defence if the defendant shall prove that the material with respect to which the contravention is alleged was at the time of the agreement for acquisition or disposal or purchase or sale or at the time of appropriation to the performance of that agreement, situate outside the United Kingdom.

(2) Notwithstanding anything contained in Article 2 of this Order: in any proceedings in respect of any alleged contravention of any revision of that Article by any sale or purchase or agreement, it shall be a defence if the defendant shall prove that the material with respect to which the contravention is alleged was under the agreement delivered or agreed to be delivered either

(i) outside the United Kingdom, or

(ii) on board a ship for exportation to some place or places outside the United Kingdom;

and in any proceedings in respect of any alleged contravention of any provision of that Article by an offer or invitation of an offer, it shall be a defence if the defendant shall prove that the offer or invitation of an offer was for the purchase or sale of material which was intended to be either

(*a*) situate outside the United Kingdom at the time of the proposed agreement for purchase or sale, or of appropriation to the performance of that agreement, or

(*b*) delivered either

(i) outside the United Kingdom, or

(ii) on board a ship for exportation to some place or places outside the United Kingdom.

4.—(1) Every person carrying on any undertaking which involves the production, treatment, keeping, storage, movement, transport, distribution, disposal, acquisition, use or consumption of any material mentioned in the First Schedule to this Order shall, upon being required so to do either by notice served on him or special or general direction issued by the Minister of Supply, keep such books, accounts, and records relating to that undertaking as may be mentioned in the notice or direction.

(2) Every person carrying on, or employed in connection with, any undertaking referred to in paragraph (1) of this Article shall, upon being requested so to do either by notice served on him or special or general direction issued by the Minister of Supply :—

(*a*) produce to such person, or a person of such class or description, as may be mentioned in the notice or direction such books, accounts, and other documents as may be mentioned or described in the notice or direction;

(*b*) furnish to the Minister of Supply such estimates, returns, and other information relating to that undertaking as may be mentioned or described in the notice or direction; and

(*c*) permit any person, or person of a class or description, mentioned in the notice or direction to enter and inspect, with a view to securing compliance with this Order, any premises used for or in connection with that undertaking.

5.—(1) Nothing in Article 2 of this Order shall be taken to prohibit or restrict the entering into and carrying out of any transaction between the Minister of Supply and any other person at such price as may be agreed between the Minister of Supply and that person

(2) For the purposes of this Order: any acquisition by or disposal to a carrier or warehouseman or servant acting in the ordinary course of his business or employment as such of any material, shall be deemed to be only an acquisition by or disposal to the person on whose behalf or to whose order the carrier or warehouseman or servant so acquires that material; and any acquisition from or disposal by a carrier or warehouseman or servant acting as aforesaid of any material, shall be deemed to be only an acquisition from or disposal by the person on whose behalf or to whose order the carrier or warehouseman or servant so disposes of that material.

6.—(1) The holder of any licence granted under this Order shall comply with any conditions contained or incorporated in the licence.

(2) If any licence granted under this Order is revoked by the Minister of Supply the holder of the licence shall forthwith deliver up the licence as directed by the Minister of Supply.

7.—(1) In this Order, the expression "Related Schedule" means any one of the related price schedules for iron and steel products lodged with the Minister of Supply for the purposes of this Order and certified as a "Control of Iron and Steel (No. 8) Order, 1940: Related Schedule No.....", by the signature (dated with the date of certifying) of the Minister of Supply: the number of which Related Schedules at the coming into force of this Order is 88.

(2) In this Order the expression "acquire" includes any acquisition of, and the expression "dispose of" includes any disposal of :—

(*a*) ownership, or any proprietary interest; or

(*b*) the right to possession; or

(*c*) possession, whether or not accompanied by any acquisition or disposal of any ownership or of any proprietary interest or of the right to possession.

8.—(1) The Control of Iron and Steel (No. 6) Order, 1940, is hereby revoked; but any licence granted under paragraph (1) of Article 1 of that Order, or of the Control of Iron and Steel (No. 4) Order, 1939, or of the Control of Iron and Steel (No. 2) Order, 1939, or of the Control of Iron and Steel (No. 1) Order, 1939, and which has not expired or been revoked, shall have effect as if it were a licence granted under paragraph (1) of Article 1 of this Order, and shall be deemed to have been so granted.

(2) This Order shall come into force on the eighth day of April, 1940; and may be cited as the Control of Iron and Steel (No. 8) Irder, 1940.

THE FIRST SCHEDULE

1. Ore (excluding Iron Pyrites and Cupreous Pyrites, but including Pyrites ash and burnt Pyrites residues whether in briquetted or other form) containing not less than 15 per cent. of iron.

2. Manganese Ore; Ore, concentrate or residue containing Molybdenum or Vanadium.

3. Ferro-Alloy of any kind, Molybdenum Metal, Calcium Molybdate, Molyte, bricks and briquetted forms of Molybdenum Dioxide and of Molybdenum Trioxide, Tungsten Metal, Tungsten Carbide, Cemented Carbide Hard Metal, Calcium Silicide.

4. Cinder and Scale produced during the manufacture or mechanical treatment of Iron and Steel.

5. Iron and Steel in any of the following forms:—

Pig; Ingot; Billet, bloom slab; Tinplate bar, sheet bar; Plate, medium plate, sheet (and whether coated or uncoated); Angle, channel, tee, joist, piling section, other sectional material (and whether fabricated or not); Round, rod, square, hexagon, flat, other section and shape (and whether black or bright); Rail, sleeper, fishplate, soleplate; Tinplate, terne plate, black plate, silver-finished plate; Hoop, strip (and whether coated or uncoated, and whether hot or cold rolled); Tube, pipe, and standard fittings therefor (and however made); Tyre, axle, wheel; Casting, block for forging, block for pressing, forging, stamping, pressing; Colliery Arch, and accessories therefor, pit prop; Bolt, nut, screw stud, washer, rivet, screw; Railway spring (and whether laminated or coiled); Bridge, pier, tank, plate and other structural steel work, in assembled or partly assembled form (and whether complete or incomplete); Wire Rod; or Coated or uncoated wire, whether (plain or barbed) wire rope, wire strand, wire netting, wire chain link fencing, wire mesh, wire nail, wire staple.

THE SECOND SCHEDULE

MAXIMUM UNITED KINGDOM PRICES FOR IRON AND STEEL PRODUCTS

Unless otherwise stated, prices set out or referred to in this Schedule, are basis prices per ton, for the quantity (if any) shewn, delivered to buyer. Other prices (related or additional) for products of the classes set out below, and extras allowances and rebates, shall be those provided for in or calculated in accordance with the Related Schedules.

IRON ORE—

	£ s. d.
All prices are f.o.t. at quarry or mine.	
(1) Hematite, for use in blast furnaces, mined in the counties of Cumberland, Lancashire and Glamorgan	1 6 3
(2) Hematite, lumpy, for use in steel furnaces	2 2 0
(3) Jurassic Ores, quarried or mined in the Frodingham district of Lincolnshire	3 9
(4) Jurassic Ores, quarried in Oxfordshire	3 0
(5) Jurassic Ores, quarried or mined in Leicestershire, Northamptonshire, Rutland or Lincolnshire (other than provided for under (3))	4 0
(6) Calcined Ore, quarried in Oxfordshire	7 0
(7) Calcined Ore, quarried or mined in Leicestershire, Northamptonshire, Rutland or Lincolnshire	8 6
(8) North Staffordshire Coal Measure	1 11 10

FERRO-ALLOYS AND ALLIED MATERIALS—

Ferro-Molybdenum and Molyte	6s. 0d. per lb. of Molybdenum content.
Calcium Molybdate	5s. 9d. per lb. of Molybdenum content.
Ferro-Tungsten 98/99 per cent.	5s. 1d. per lb. of Tungsten content.
Tungsten Powder	5s. 2½d. per lb.
Ferro-Vanadium	15s. 6d. per lb. of Vanadium content.

CINDER AND SCALE—

	£ s. d.
(a) Produced in the United Kingdom and delivered carriage paid at any iron or steel works in England or Wales:—	
Good Clean Scale	1 7 6
Ball Furnace Cinder containing not less than 68 per cent. iron	1 7 6
All other Cinder	1 2 6
(b) Produced and used in Scotland—f.o.t. producers' works:—	
Mill Cinder	9 0
Puddle Tap	11 0
Steel Cinder	13 6
Scrap Tap	15 6
Scale	15 6

PIG IRON—

	£ s. d.
Basic—delivered station or siding to:	
(a) South Wales, N.E. Coast, Scotland, Mersey Ports, Lancashire, Cheshire, N. Wales and North Staffs.	5 4 6
(b) Yorkshire, including Sheffield (other than provided for under (a)	5 7 0
(c) South Staffordshire and all other districts	5 9 6
Hematite.—No. 1 Mixed Nos., S. & P. over 0·03 per cent. but not exceeding 0·05 per cent.—delivered station or siding:—	
(a) Scotland, N.E. Coast and West Coast of England	6 7 6
(b) Sheffield	6 13 0
(c) Birmingham	6 19 0
(d) Wales—Welsh Iron	6 3 0
Foundry and Forge—delivered station or siding:	
(1) No. 3 Iron, Class 2—	
(a) Middlesbrough	5 11 0
(b) Birmingham	5 13 0
(2) Phosphorus 0·5 per cent. to 0·75 per cent.—Birmingham	6 0 6
(3) Phosphorus 0·1 per cent. to 0·5 per cent.—Birmingham	6 9 9
(4) Scotch Foundry Iron—f.o.t. producers' works	5 12 6
Cylinder and Refined—	
(a) North Zone	7 19 0
(b) South Zone	8 1 6
Refined Malleable:	
Cold Blast—	
(a) South Staffordshire	10 5 0
Birmingham and South Staffordshire stations	7 16 6
FORGING INGOTS up to 0·60 per cent. C.	11 0 6

BILLETS, BLOOMS AND SLABS FOR RE-ROLLING—

	£ s. d.
Basic—	
(a) Soft U.T. (100-ton lots)	9 7 6
(b) Soft T.G. up to 0·25 per cent. C. (100-ton lots)	9 12 6
(c) Hard, 0·42 per cent. to 0·60 per cent.	10 10 0
(d) Silico-manganese	13 2 6
(e) Free-cutting	11 2 6
Siemens Martin Acid—	
(a) Up to 0·25 per cent. C.	12 7 6
(b) Case Hardening	13 5 0
(c) Silico-manganese	13 2 6

BILLETS, BLOOMS AND SLABS FOR FORGING, DROP FORGING, AND STAMPING—

	£ s. d.
(a) Basic Soft, up to 0·25 per cent. C.	11 0 0
(b) Basic Hard, 0·42 per cent. to 0·60 per cent. C.	11 7 6
(c) Acid, up to 0·25 per cent. C.	12 17 6
(d) Acid Case Hardening	13 15 0
(e) Acid Silico-manganese	13 12 6

ALLOY STEELS—

	Nickel 0·6–1 per cent.	Nickel-Chrome Ni 2·75–3·75 Cr 0·6–1·25 per cent.	Nickel-Chrome Molybdenum Ni 2·75–3·75 Cr 0·6–1·25 Mb 0·20–0·60, per cent.
	£ s. d.	£ s. d.	£ s. d.
Billets, 2in. up to and including 10in.	16 2 6	27 17 0	34 13 0
Stamping Bars, ½in. diam. and up, round or equivalent sectional area	22 3 0	35 4 6	43 3 6

STAINLESS STEEL AND IRON

Steel Billets, 2 in. and larger, square and gothic sections	*Austenitic* 11d. per lb. / *Martensitic* 7½ per lb.

HIGH SPEED STEEL—

	14 per cent. Tungsten Per lb.	18 per cent. Tungsten Per lb.	22 per cent. Tungsten Per lb.
	s. d.	s. d.	s. d.
Bars	3 0	3 10	4 4

	£ s. d.
TINPLATE AND SHEET BARS—Delivered station or siding in not less than 6 ton lots	9 5 0

WIRE RODS—

	£ s. d.
Basic.—All sizes with exception of 6 gauge and over 7/0 gauge and delivered in all districts in United Kingdom except (a) Birmingham and Scotland, and (b) Southern Joint Area:—	
Soft Basic 0·08 per cent. to 0·25 per cent. C.	13 15 6
Hard Basic, 0·42 per cent. to 0·60 per cent. C.	16 18 0
Free-cutting	15 18 0
Acid.—Up to 0·85 per cent. C. all sizes with exception of 6 gauge and over 7/0 gauge, delivered all districts:—	
Ordinary	20 9 0

MANUFACTURED IRON—

	Crown Iron £ s. d.	No. 3 Bars £ s. d.	No. 4 Bars £ s. d.
(a) English and Welsh delivery, usual districts	14 2 6	11 7 6	11 17 6
(b) Scottish delivery, usual districts	14 2 6	12 10 0	12 15 0
(c) Irish delivery, f.o.q., Belfast	14 15 0	12 0 0	12 10 0

HEAVY STEEL PRODUCTS—

Deliveries to the following Principal Districts:—	Joists and Angles £ s. d.	Plates £ s. d.	Boiler Plates £ s. d.
(a) North-east Coast, Northern Joint Area, Scotland, Belfast shipyards and shipbuilders at Thorne, New Holland and Gainsborough	12 8 0	12 10 6	13 8 0
(b) Leeds and District, Midland Area and and South Wales	12 8 0	12 13 0	13 10 6
(c) Southern Joint Area	12 10 6	12 15 6	13 13 0
Medium Plates (under $\frac{3}{16}$in. thick) all deliveries:—			
Weighing 6 lb. or more per sq. ft.	—	14 0 0	—
Weighing less than 6 lb. but not less than 4·81 lb. per sq. ft.	—	14 10 0	—
Chequered Plates (¼in. thick and upwards) delivered to:—			
(a) North-east Coast and shipbuilders at Thorne, New Holland and Gainsborough	—	14 0 6	—
(b) Northern Joint Area, Scotland, Leeds and District, Midlands and South Wales, Southern Joint Area	—	14 3 0	—

RAILS—

	£ s. d.
Heavy Rails.—60 lb. per yard and over, lots of 500 tons and over; f.o.t. Maker's works	11 3 0
Light Rails.—Light flange rails, up to and including 25 lb. per yard	13 6 6

	£ s. d.
COLLIERY ARCHES AND ACCESSORIES—4 by 2½ by 2 and 4 by 2½ by 2½, single radius with straight horseshoe, or splayed legs with one fishplate joint, complete with one pair of fishplates and the necessary bolts and nuts	13 18 6
Arches as above but *without* fishplates, bolts and nuts	13 16 0
Fishplates (for Arches) alone	19 0 0
Plain Cambered Girders, 4 by 2½ by 2 and 4 by 2½ by 2½ with minimum camber of 2in. in centre, for use underground only	13 11 0
Corrugated Straps, Roofing, or Benk Bars	12 12 6

RE-ROLLED STEEL PRODUCTS—

	£ s. d.
Angles and Tees 4 united inches and under, and *Channels* 3in. web and under: Basis U.T.	13 10 0
Bars—Flats 5in. wide and under and *Rounds and Squares* under 3in. U.T.	14 0 0
Free-cutting Bars—Rounds	15 12 0
Hoop and Strip—hot rolled (excluding hoop and strip for Gas, Steam and Water Tubes) U.T.	14 15 0
Hoop and Strip—cold rolled basis. Hard Bright—in coils (not annealed)—1½in. to 6in. by 0·032in. and thicker	21 16 0
Products made from Basic Hard Steel—0·42 per cent. to 0·60 per cent. C.	15 0 6
Products made from Siemens Martin Acid Steel—Up to 0·25 per cent. C.	16 18 0
Spring Steel Bars—	
Laminated—	
(a) Basic 0·42 to 0·60 per cent. C. Water Hardening	15 0 6
(b) Acid 0·42 to 0·60 per cent. C. Water Hardening	18 11 6
Siemens Martin File Steel—	
Long lengths 12in. and up—	
(a) Acid	20 3 0
(b) Basic	17 10 0
Ferro-concrete Bars—delivered station or siding	13 7 6

RE-ROLLED STEEL PRODUCTS (*continued*)—

	£ s. d.
Rivet, Bolt and Nut Bars (4 ton lots)	14 3 0
Glazing Tees—special Glazing Bulb or long Stalked Tees	17 13 0
Sash and Casement Sections—Mains Standard Cottage Zeds	17 6 0
Gate Channels	16 4 0

BRIGHT STEEL—

	£ s. d.
(a) Mild Steel to no analysis or tests	19 15 0
(b) Tested and guaranteed, 28 tons to 32 tons tensile	20 15 0
(c) Free-cutting, B.S.S. 32, Grade 4	21 11 6
Flats—not tested or guaranteed	29 10 0

SHEETS—

	£ s. d.
(a) Black, 24 G.—4 tons and over of basis quality	17 10 6
(b) Galvanised, corrugated, 24 G.—4 tons and over of basis quality	20 16 3

TINPLATE, TERNEPLATE AND BLACKPLATE—

	£ s. d.
Tinplate—Coke quality per basis box (I.C. 20 by 14—112 sheets—108 lb.), f.o.t. Maker's Works	1 4 9
Terneplate—Unassorted Light Ternes ordinary quality sold per basis box (28 by 20, 121 sheets, 216 lb.) f.o.t. Maker's Works	2 5 9
Blackplate—Rectangles, unassorted, C. A. quality, 28/14 per ton delivered Birmingham	18 6 3

TUBES, PIPES, AND FITTINGS—

Gas List Wrought Iron and Steel Tubes and Fittings.
Loose Flange Joint Tubes.
Wrought Iron and Hot Finished Steel Boiler Tubes.
Steel Pipes to B.S.S. 534. Table 1.
A.P.I. Line Pipe.
Malleable Pipe Fittings.
Steel Conduit Tubes.
Vertically Cast Iron Pipes and Spun Iron Pipes.
Standard Socket and Spigot Special Castings.
Cast Iron Drain Pipes.
Cast Iron Drain Pipe Fittings.
Angle Cast Iron Pipes for Gas and Water Purposes.

The prices stated in the Standard lists and Related Schedules less any discounts provided for in the Related Schedules.

WIRE AND WIRE PRODUCTS—

	£ s. d.
Mild Steel Wire.—Catch weight coils 6/8 standard wire gauge for sale by makers in 2-ton lots:	
Hard drawn	18 0 0
Mild drawn	19 10 0
Annealed	19 10 0
Galvanised Barbed Wire.—2 or 4 point, 2 ply, 12½ gauge for sale by makers in 2-ton lots	27 0 0

FORGINGS—

Prices set out in the Related Schedules plus the percentage additions in operation at November 1st, 1939, plus a further 6 per cent.

STEEL CASTINGS—

Prices set out in the Related Schedules plus 13s. 4d. per ton.

TYRES, AXLES, AND SOLID WHEELS—

Prices set out in the Related Schedules plus 25s. per ton.

RAILWAY COIL SPRINGS—

		£ s. d.
Spiral Buffer and Draw Springs.		
R.C.H. Drawing No. 209A/1	each	9 7
R.C.H. Drawing No. 209A/2	each	1 2 7
Volute Buffer and Draw Springs.		
R.C.H. Drawing No. 209A/8	each	11 1

LAMINATED RAILWAY SPRINGS—

	£ s. d.
Bearing Springs.—5 plate, ordinary wagon 4in. wide by ½in. plates, but with back plates ½in. thick	28 7 6
Buffing Springs.—14 plate with double double lug hoops	30 5 0

IRON CASTINGS WHICH HAVE NOT BEEN SUBJECTED TO ANY PROCESS OTHER THAN MOULDING, FETTLING, ANNEALING, OR PAINTING—

(a) For Rainwater and Soil Goods, Gutters, and Connections—the prices set out in the Related Schedules; and

(b) For products not covered as such by any Related Schedule—the Sellers' latest price ruling in 1939 before September 1st, 1939:—

with the addition in both cases (a) and (b) of 8 per cent. plus 13s. 4d. per ton or an equivalent percentage, and also of any appropriate extras set out in the Related Schedules for alloy additions.

THE CONTROL OF IRON AND STEEL (NO. 8) ORDER, 1940, DIRECTION (NO. 1).

Under the Control of Iron and Steel (No. 8) Order, 1940, I hereby issue the following direction:—

1.—(a) Notwithstanding anything in paragraph (1) of Article 1 of the Order:—

(i) iron ore mined or quarried in the United Kingdom, pyrites ash and burnt pyrites residues;

(ii) manganese ore;

(iii) tanks and cylinders of which every sheet or plate is under $\frac{3}{16}$in. thickness; and

(iv) boot and shoe grindery and machine staples;

may until further notice by acquired for use in the United Kingdom without licence, and disposed of accordingly.

(b) Notwithstanding anything in paragraph (1) of Article 1 of the Order:—

(i) iron castings (except tubes, pipes, and tube and pipe fittings) which have been subjected to any process other than moulding, fettling, annealing, or painting; and

(ii) pressings;

may until further notice by acquired without licence, and disposed of accordingly.

(c) Notwithstanding anything in paragraph (1) of Article 1 of the Order, tube and pipe fittings supplied with and for assembly with a tube or pipe may, until further notice, be acquired without licence when the tube or pipe with which they are supplied is acquired under the provisions of paragraph 2 of this Direction, and so disposed of accordingly.

2. Notwithstanding anything in paragraph (1) of Article 1 of the Order, steel in any of the following forms:—

Ingot; Billet, bloom, slab; Plate, medium plate (and whether coated or uncoated); Sheet (and whether coated or uncoated); Angle, channel, tee, joist, piling section, other sectional material (and whether fabricated or not); Round, rod, square, hexagon, flat, other section and shape (and whether black or

bright); Rail, sleeper, fishplate, soleplate; Tinplate, terne plate, black plate, silver-finished plate; Hoop, strip (and whether coated or uncoated, and whether hot or cold rolled); Tube, pipe (including imported hollows); Tyre, axle, wheel; Casting, forging, stamping; Colliery arch and accessories therefor, pit prop; Bolt, nut, screw stud, washer, rivet, screw; Railway spring (and whether laminated or coiled); Wire Rod; and Coated or uncoated wire (whether plain or barbed), wire rope, wire strand, wire netting, wire chain link fencing, wire mesh, wire nail (excluding boot and shoe grindery) and wire staple (excluding machine staple)—

may until further notice :—

(i) be acquired without licence by :—

(*a*) any "Department" named in the Second Column of the list of symbols printed on page 337, THE ENGINEER, April 5th, to this Direction which gives to the person from whom it acquires that steel a written and dated order therefor headed—"Control of Iron and Steel—Distribution Scheme. 'Department' Symbol (*stating the symbol allotted to that 'Department' in the First Column of the said Appendix*). Contract or Reference Number (*stating the contract or reference number selected by that 'Department'*). Delivery Period (*stating the number or numbers selected by that "Department"*)" and signed "On behalf of (*name of 'Department'*)" by a person authorised by the "Department" so to sign; and

(*b*) any person who, being authorised in writing by the Minister of Supply or any "Department" aforesaid so to do, gives to the person from whom he acquired that steel a written and dated order therefor headed —"Control of Iron and Steel—Distribution Scheme. 'Department' Symbol (*stating the aforesaid symbol of the authorising 'Department'*). Contract or Reference Number (*stating the contract or reference number selected by the authorising 'Department'*). Delivery Period (*stating the number or numbers selected by the authorising 'Department'*)" and signed by that person: Provided that any person who acquires any steel under this Paragraph of this Direction shall not treat use or consume such steel for any purpose other than a purpose for which the aforesaid authority was given; and

(*ii*) be disposed of by any person to any "Department" giving, or to any person authorised by the Minister of Supply or such a "Department" to give and giving, to the persons disposing, the written and dated order prescribed for such "Department" or person in head (i) of this paragraph: Provided that the person disposing shall take from the "Department" or person acquiring, and keep, the said order and when so required deliver that order to the Minister of Supply or as he may direct.

Provided that nothing in this paragraph shall authorise—

(i) the acquisition of steel in any of the forms set out above for conversion into any other of the forms set out above; or

(ii) a stockholding merchant to acquire any material included in the First Schedule to the Order; except material delivered directly from the supplier of the stockholding merchant to a customer of the stockholding merchant.

3. Notwithstanding anything contained in paragraph (1) of Article 8 of the Order: any licence deemed by virtue of the provisions of that paragraph to have been granted to a stockholding merchant for steel in any form set out in paragraph 2 of this Direction, is hereby revoked.

4. Notwithstanding anything in paragraph (1) of Article 1 of the Order, any material included in the First Schedule to the Order, other than—

(i) ferro-vanadium;
(ii) pig-iron; and
(iii) any material mentioned in Paragraph 2 of this Direction;

may until further notice be acquired without licence by (and disposed of accordingly to) :—

(*a*) by any Government Department—for any purpose; and

(ii) by any person having a contract with a Government Department or a sub-contract under such a contract—for use by that person directly in the fulfilment of that contract or sub-contract; and

(*b*) (i) the following undertakings or persons for the execution in the United Kingdom of the purposes stated in respect of them; that is to say :—

any person—for the purpose of fulfilling an obligation imposed on that person by the Civil Defence Act, 1939 for Air Raid Precautions;

any railway undertaking under the control of the Minister of Transport by virtue of any Order made under the Defence (General) Regulations, 1939—for the purposes of that undertaking;

any electricity generating station generating for public supply—for the purposes of that station;

any public utility undertaking within the meaning of Regulation 100 of the Defence (General) Regulations, 1939, and not before mentioned in this paragraph—for repair work and maintenance work for the purposes of that undertaking;

any shipbuilder, ship-repairer, marine engineer, or marine boilermaker—for the building, repairing or equipment of any ship; shipowner—for the repair or maintenance of any ship;

mine or quarry undertaking—for mining or quarrying in any mine or quarry of that undertaking;

agricultural machinery or implement maker or repairer—for making or repairing any agricultural machinery or implement for use in the United Kingdom;

locomotive builder or repairer—for building or repairing any locomotive for use in the United Kingdom;

wagon builder or repairer—for building or repairing any railway wagon for use in the United Kingdom;

iron or steel works or foundry or forge—for repair or maintenance thereof; and

producer of refractory material—for repair or maintenance of any Refractory Works owned or operated by him; and

(ii) by any person having a contract with an undertaking or person mentioned in sub-head (i) of this head (*b*) or a sub-contract under such a contract—for use by that person directly in fulfilment of that contract or sub-contract;

Provided that nothing in this Paragraph shall authorise a stockholding merchant to acquire any material included in the First Schedule to the Order; except material delivered directly from the supplier of the stockholding merchant to a customer of the stockholding merchant.

5. Notwithstanding anything contained in paragraph (1) of Article 1 of the Order or in Paragraph 2 or 4 of this Direction :—

(*a*) a merchant may without licence acquire any material mentioned in any licence to acquire that material being a licence granted to a stockholding merchant—for the purpose of supplying that material to that stockholding merchant for stock;

(*b*) any material included in the First Schedule to the Order, other than

(i) ferro-vanadium; and

(ii) pig-iron;

may be acquired without licence by (and disposed of accordingly to) any person (provided that such person shall not be a person authorised to acquire that material under Paragraph 2 (i) (*b*) of this Direction) making a purchase from the stock actually held at the time of such purchase by a stockholding merchant—for the execution in the United Kingdom of any purpose;

(*c*) Government Departments, undertakings, and persons who, immediately before the coming into force of the Order, were both

(i) Government Departments, undertakings, or persons referred to in head (*a*) or (*b*) of paragraph 2 of the Control of Iron and Steel (No. 6) Order, 1940, Direction No. 1 and

(ii) parties to a contract made for any purpose referred to in respect of them in those heads,

may, up to and including May 31st, 1940, without licence acquire, for the purpose of performing that contract, the material required for that performance; and any person not being a person who has before been referred to in this sub-paragraph, may, if a party to any such contract, dispose of that material to any other party to that contract; and

(*d*) by any person making purchases of any material included in any one of the following categories not exceeding the quantity specified against each category nor £10 in value (further purchases of material in such category not being permitted in the same week) may until further notice aquire without licence such material (which may be disposed of to him accordingly)—for the execution in the United Kingdom of any purpose :—

Category	Description	Quantity
(i)	Ferro-alloy of any kind	5 cwt.
(ii)	Calcium Molybdate	56 lbs.
(iii)	Molyte	56 lbs.
(iv)	Tungsten metal	56 lbs.
(v)	Tungsten carbide	10 lbs.
(vi)	Cemented carbide hard metal	2 lbs.
(vii)	Calcium silicide	5 cwt.
(viii)	Tinplate	6 cwt. or 3 double boxes
(ix)	Terne plate	6 cwt. or 3 double boxes
(x)	Black plate	5 cwt.
(xi)	Silver-finished plate	5 cwt.
(xii)	Iron casting	5 cwt.
(xiii)	Bolt, nut, screw stud, washer	2 cwt.
(xiv)	Rivet	2 cwt.
(xv)	Screw	2 cwt.
(xvi)	Bridge, pier, tank, plate, and other structural steel work, in assembled or partly assembled form (and whether complete or incomplete)	2 cwt.

6.—(1) Sub-paragraph (*c*) of Paragraph 1, Paragraph 2 (but without prejudice to the interpretation of Paragraph 3 of this Direction), and item (iii) at the beginning of paragraph 4 of this Direction, shall come into force on April 29th, 1940; but the remainder of this Direction shall come into force on April 8th, 1940.

(2) This Direction may be cited as the Control of Iron and Steel (No. 8) Order 1940, Direction No. 1.

Explanatory Memorandum

1. The main purpose of this new Order is to give legal effect to the Scheme for Distribution of Steel Supplies, under which the steel products covered by that Scheme can be acquired by the quotation, when duly authorised, of the symbol, contract or reference number and delivery period to the Seller. This question is referred to in greater detail when dealing with the Direction (No. 1) published with the Order.

2. The Order itself contains a number of alterations in its wording which are not referred to particularly in this Memorandum, because they have been introduced mainly to bring the language of the Order in accord with the standard form now in use by the Ministry of Supply. The main features of previous Orders are retained in that Article 1 deals with licensing, and Article 2 with the fixing of maximum prices.

The Direction has to be referred to for the exemptions from licence of certain materials, including those products which come under the Scheme for Distribution of Steel Supplies.

The Second Schedule and the Related Schedules set out the maximum prices.

3. Article 3 deals in part with the materials and products, imported from abroad, which are free from Iron and Steel Control licence, because they are covered by the necessity of obtaining an Import Licence.

Paragraph (2) of this Article 3 exempts from maximum price material to be delivered abroad or aboard ship for export.

4. Article 4 repeats in altered form the obligation to keep and produce books, furnish returns, and permit inspection.

5. Article 5 exempts the Ministry of Supply from the provisions in regard to maximum price, but still leaves the Departments of the Ministry subject to the various provisions in regard to licensing, exemption from licence, obligation to quote symbol, contract or reference number and delivery period, in the same manner as other Government Departments.

6. The Order comes into force on April 8th, 1940, but the operation of Paragraph 2 of the Direction, under which symbol, contract, or reference number and delivery period are to be used for all new orders (*i.e.* placed on or after April 8th, 1940) for steel products, is postponed until April 29th, 1940. In respect of old orders (*i.e.* placed before April 8th, 1940) the application of this Paragraph 2 is further postponed until May 31st, 1940. The position therefore is that by April 29th, 1940, all new orders for steel products covered by Paragraph 2 must be authorised by a symbol, contract, or reference number and delivery period and all old orders must be given this authority by May 31st, 1940. It is emphasised that this latitude has only been given to enable the carrying out of orders where a symbol, contract, or reference number or period number cannot be obtained immediately and all orders must be so authorised at the earliest possible moment.

7. The First Schedule remains unaltered save that ores containing Tungsten have been deleted from the products to licence, in view of the setting up by the Ministry of Supply of the Chrome Ore, Magnesite, and Wolfram Control.

8. Attention is called to increases under the Second Schedule in the price of certain more highly finished products, notably Crown Iron, Colliery Arches and Accessories, Galvanised Sheets, Tubes and Pipes, certain types of Wire and Wire Products, Steel Castings and Railway Coil, and Laminated Springs.

9. The Direction made simultaneously with the issue of the new Order differs from the previous Direction to the (No. 6) Order in certain important respects and the main provisions are now as follows :—

(*a*) All Manganese Ore is exempt from Ministry of Supply Licence but remains subject to Board of Trade Import Licence. Machine Staples have been added to boot and shoe grindery as being free from a Supply Licence.

(*b*) The four items in sub-paragraph (*a*) of Paragraph 1 are exempt from Ministry of Supply Licence if acquired for use in the United Kingdom.

(*c*) The two items, iron castings (except tubes) and pressings are exempted from licence whether for use in or out of the United Kingdom.

(*d*) Paragraph 2 of the Direction introduces one of the main provisions of the Scheme for Distribution of Steel Supplies in that the steel products covered by that Scheme may until further notice be acquired

without licence against an order from any Department named in the Appendix to the Direction quoting the "Department" symbol, contract or reference number and delivery period, or any order from any other person authorised so to quote by the Ministry of Supply or any "Department."

(*e*) Provision is made that the Supplier shall take from the Purchaser an order under which these symbols, contract, or reference number and delivery period are quoted, and, if required, deliver it to the Ministry of Supply, that is to say the Iron and Steel Control. This will enable the Control to check that supplies obtained under these provisions are so obtained with proper authority.

(*f*) At the end of Paragraph 2 it is made clear that a stockholding merchant may only acquire material without licence where the goods are delivered directly from his supplier to his customer. In cases of this kind where steel products covered by the Scheme are acquired, the Stockholding Merchant must pass on to his supplier the symbol, contract, or reference number and delivery period obtained from his customer.

(*g*) It will be noted that although this Paragraph 2 dealing with the Distribution of Steel Supplies allows the acquisition of material without licence, in accordance with the Scheme, it does not prevent the granting of licences for the products covered by that Scheme in any particular case. It is envisaged, however, that although licences may be required for such Steel Products during the transition period II, that is from April 1st to June 30th, 1940, it is not intended that thereafter licences will be issued where supply by authorised quotation of symbol, contract, or reference number and delivery period, can be obtained.

(*h*) Paragraph 4 of the Direction, which continues the old system of exemptions from licensing, is made, therefore, to apply to those products not covered by the Scheme for Distribution of Steel Supplies dealt with under Paragraph 2 of Direction (No. 1). It is important, therefore, that it should be appreciated that steel products covered by such Scheme can be acquired only on the quotation of an authorised symbol, contract, or reference number and delivery period or on the authority of a Licence. Where Licences are required and there is a symbol, contract or reference number and delivery period as well, these should also be quoted.

(*i*) Under Article 8 of the Order, all licences already granted are to be deemed to have been granted under this new Order (No. 8). Paragraph 3 of the ngw Direction therefore revokes all previous licences granted to Stockholding Merchants for stock, to accord with the Scheme for Distribution of Steel Supplies and these should be returned to the Iron and Steel Control.

(*j*) Paragraph 4 of Direction (No. 1), as has been indicated exempts Government Departments for any purpose, and certain undertakings or persons and direct contractors and sub-contractors therefor, in the same way as in the past, from requiring a licence to obtain supplies other than those steel products covered by the Scheme for Distribution of Steel Supplies under Paragraph 2 of the Direction.

(*k*) Under Paragraph 4 it is similarly made clear that nothing authorises a stockholding merchant as such to acquire material without licence save in his merchanting business where goods are delivered directly from supplier to customer.

(*l*) Paragraph 5 of the Direction provides for the acquisition without quotation of a symbol, &c. and without licence of any material ordered by a merchant for supply to a duly licensed stockholding merchant for stock to be used in the United Kingdom.

(*m*) Paragraph 5 of the Direction also provides for purchases without licence or quotation of a symbol, &c. from the actual stock of a stockholding merchant and for small purchases of the categories and quantities set out at the end of the Direction.

SHORT-CENTRE ROPE DRIVE.—In the article in our issue of April 5th, describing a short-centre rope drive at Brown, Bayley's works at Sheffield, we stated that the driving unit was designed and supplied by R. and F. Dick, Ltd. We should, of course, have said R. and J. Dick, Ltd.

NEW SWEDISH SHIP MODEL TANK.—Part of the new laboratories of the Chalmers Technical High School at Gothenburg will include a ship model tank 847ft. long by 34ft. wide and having a depth of 17ft. The travelling platform carrying the recording instruments will be capable of the unusually high speed of 14 m. per second.

VACUUM DRYING OF FOODSTUFFS.—Rapid freezing, with subsequent storage at low temperatures, is probably the most effective way of preserving the desirable properties of foodstuffs. If, however, the moisture present in the frozen foodstuffs in the form of ice is removed by evaporation in a high vacuum, the desiccated products can be transported and stored without the need for refrigeration, and there is in addition a large saving of weight. In view of these possibilities, a small-scale plant, designed to dry foodstuffs at low temperatures, has been in operation at the Low Temperature Research Station during the past year on behalf of the Food Investigation Board of the Department of Scientific and Industrial Research. Many different foods have been dried, such as fruit, vegetables, fruit-juices, meat, eggs, butter, and milk, and it is now clear that the products obtained are in general superior to those obtained by other methods of drying.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quantities are f.o.b. steamer.

Pig Iron Market

The demand for pig iron is steadily increasing and there seems a possibility that it may reach a point at which it will be in excess of the capacity of the producing works. There are, of course, no statistics available either of the production or of the number of furnaces in blast, but whilst it is known that the output has been increased since the beginning of the war, there is no method of estimating the relative volume of production and demand. There is no doubt, however, that some stringency exists in the supply of basic pig iron, and that the steelmakers are worried at the possibility of this becoming more acute in the future. Arrangements have been made, however, for the importation of good tonnages and apart from the unlikely event of an interruption to foreign supplies it is probable that the situation will then become easier. In most districts the producers have concentrated upon the output of steel-making iron and this has now reached a high level. So enormous is the steel production, however, that all the iron produced is immediately taken up by consumers. The situation in the hematite market also is becoming tight and the demand for this quality is increasing as the war effort gathers impetus. The makers are understood to hold comparatively small stocks, and lately users have shown a natural tendency to cover their forward requirements. The foundry iron market is irregular. Low phosphoric qualities are in active demand, but business in high phosphoric grades hangs fire. The former is needed by the engineering foundries in considerable volume and the request for it is probably slightly in excess of the production. The careful method of distribution by the Control, however, has avoided any serious interruption to supplies and no consumer, so far as can be ascertained, has had to go short. In fact they appear to have been well looked after although they have not been able to accumulate reserves. On the North-East Coast the production of Cleveland foundry iron has ceased, and the foundries in that district are relying upon Midland irons. The light castings foundries, however, are only moderately well employed and are still hoping that steps will be taken to provide them with war work. The possibility of an improvement in the building trade has been welcomed in this department as it may lead to a more active call for their products. In the Midlands the light castings foundries are taking a fair amount of foundry pig iron, but works operations are irregular and this is reflected in the pig iron requirements of the industry. In Scotland the foundries are working on short time, and are providing only a disappointing outlet for pig iron. Stocks are said to have accumulated to some extent at the producing works. Considerable quantities of Midland pig irons are reaching Scotland.

The North-East Coast and Yorkshire

Interest on the North-East Coast is concentrated upon the operation of the new scheme for the distribution of steel. It is regarded as being a rather complicated plan, but the general view is that it should be tried out before any criticism is offered. In the meantime the situation presents no change. Many of the works are in arrears with deliveries and it may take some time before even under the new scheme they can get square with their contracts. All the plant on this coast is in full operation, and the production of all departments is at a very high level. No statistics of output are published, but it is understood that the output of finished steel is at a rate never before attained. In particular the demand for structural steel seems inexhaustible. The constructional engineers have a large amount of work in hand in the way of extensions to plant and new Government buildings, and it is probable that further contracts will be given out in the near future. This work absorbs a tremendous tonnage of joists and sections, and the general view is that there is no likelihood of the demand receding for a long time. Recently, new business has been less active but this is due to the difficulty of placing orders rather than because of any lessening in requirements. There is a heavy demand for all classes of shipbuilding steel, which is likely to be maintained at a high rate for many months owing to the big Admiralty programme of naval and merchant shipbuilding. Business in plates has had a quieter appearance of late, the reason being that the mills' order books are so congested that few of them are in a position to accept fresh business. In fact an order must have strong backing and be of an urgent character to receive attention from the plate makers. The quantities passing into consumption are large and are distributed over all the consuming industries including the shipyards, boiler, and tank makers and locomotive builders. The Yorkshire steel trade is working at capacity, and the makers continue to experience great pressure from consumers to secure deliveries. The demand for basic steel is particularly heavy, and the works making this material are falling into arrears. Business in acid carbon steel is also on a heavy scale. The works producing soft basic billets are operating at capacity, but even so are not able to keep abreast of the demand. Special steels are being bought in quantities and there is a considerable business in stainless steel.

The Midlands and South Wales

So heavily booked are the steelworks in the Midlands that consumers find great difficulty in placing new orders. Most of the steel mills are understood to have sufficient work on their books to keep them busy for several months. The situation presents little change in other respects as the demand seems to be largely concentrated upon structural steel of all classes. Steel bars are in active request, and in spite of the large production consumers find a difficulty in securing their full requirements. Large tonnages of ferro-concrete bars are also passing into consumption. Practically the whole output of structural steel is required directly or indirectly for war work and material for ordinary commercial purposes is difficult to secure. It is expected that the demand for bars, joists, angles, and other sections will increase rather than diminish as time goes on and the Government's programme for building additional factories proceeds. Whilst there is still some complaint that the re-rollers are not obtaining all the billets they require, generally speaking they are in a better position than for a long time past, as supplies of imported semis have been distributed with greater freedom. This easing in the stringency with regard to semi-finished steel has been welcomed since practically all the works had full order books and the consequent expansion in outputs has helped consumers. The sheet works are experiencing a steady and strong demand and are kept fully employed. Although the demand for A.R.P. material has been largely satisfied, war requirements of other descriptions have been coming forward to take the place of the former contracts. Export business, although not so pressing as a few months ago, is still offered with some freedom, but unfortunately the works are not in a position to take advantage of this class of business owing to the importance of the home demand. Colliery requirements have shown no signs of a decline, and owing to the stringency in the supplies of timber the demand for steel from this industry has grown considerably since the commencement of the war. The pressure for supplies of props, roofing bars, and arches continues insistent. The South Wales steelworks are operating as fully as the supplies of raw materials will permit. Lately there has been some improvement in the production of steel but the demand also appears to have increased. Shipbuilders, ship repairers, and constructional engineers in Wales are insistent in their demands for structural steel and plates. The request for tinplates has lessened somewhat of late, and this is partly attributed in the case of the export markets to the long periods required for delivery. Some of the tinplate works have found supplies of steel rather stringent and it is hoped that under the new scheme their allocations will be on a more generous scale.

Overseas Trade Opportunities

The Department of Overseas Trade announces that the following contracts are open for tender. Local representation is essential in most instances. Singapore Municipal Water Department: supply and delivery of 30in. straight steel pipes and specials (Singapore, April 16th). South Africa, Durban General Stores Dept.: Supply and delivery of six flow meters with 1in. diameter outlet and suitable for use with fuel oil as used in compression ignition motor vehicles, each meter to be fitted with a vertical 10in. reading dial giving a progressive total in imperial gallons and having a quantity setting device (Durban, April 19th). South African Railways and Harbours, Stores Dept.: supply and delivery of one mild steel parachute water tank of 4000 gallons capacity (Johannesburg, April 25th). Indian Stores Dept.: supply of one heavy oil engine for Chappri pumping station (Department of Overseas Trade, reference number T.Y. 17871/40). Australia, State Electricity Commission, Victoria: supply of a complete feed water plant for the Newport "C" power station (Australia, April 30th). Cairo, Ministry of Public Works Mechanical and Electrical Dept.: supply and delivery of a suction dredger with agitator (Cairo, May 1st). South African Railways and Harbours Administration: supply and delivery of two 15-ton level luffing electric portal travelling wharf cranes, with 4-ton auxiliary hoist for Durban Harbour. The system of electricity supply will be 380 volts, three-phase (220 volt, single-phase) 50 cycles, 4 wire; structural steelwork for extension at Buffalo Harbour (Johannesburg, May 6th). Argentine National Sanitation Works Dept.: supply of sewage plant (Buenos Aires, May 13th). Orders for steel rails and fishplates aggregating three-quarters of a million pounds including freightage have been placed by the South African Railways and Harbours Administration with two Canadian firms. One order for 57,000 tons of steel rails valued at £570,000 has been divided between the Dominions Steel Corporation and the Algoma Steel Corporation, Ltd., whilst a second order for 85,000 pairs of fishplates to the value of £41,000 has been given to the Algoma Steel Corporation. Of the orders placed in July last year for 66,000 tons of steel rails to a total value of £601,000, net, more than one-third went to these two firms, the bulk being placed with United Kingdom firms.

Copper and Tin

In this country the copper situation has remained unaltered, and supplies continue to come forward on a satisfactory scale. Firms engaged upon war work find that their requirements are well looked after by the Control, but those works which need copper for ordinary commercial purposes frequently have difficulty in obtaining metal. This is understandable since the Copper Control naturally has to provide metal for firms engaged upon war work and at the same time take precautions against any shortage. Conditions in the world market have grown particularly dull and little business has been transacted. In the United States the quotation is officially called 11·10c. but business has been reported down to 11·05c. Neutral buying in the United States has been light. This is attributed partly to the British contraband control, and also to the fact that many producers are not particularly anxious to sell copper which might find its way to Germany. The big producing companies are understood to be well sold for some time to come and for that reason are not actively pressing sales. . . . Prices in the tin market have moved rather erratically, but there has been no very wide movement. This has been largely due to sharp fluctuations in the East. Later the price in London became steadier although the backwardation increased owing to the decline in the official stocks. American buying has not been particularly active, but at the lower prices in the early part of this week some fair purchases were made. Some buying has also been reported by the Welsh tinplate works. The statistics issued by Mr. W. H. Gartsen showed a reduction at the end of March in the visible supply of 885 tons, to 22,980 tons compared with 23,865 tons at the end of

February. The supplies during March amounted to 15,961 tons compared with 11,863 tons in February. Of this total 10,092 tons was represented by shipments from the Straits to the United States. The deliveries during March were given as 16,846 tons against 12,796 tons in February. Of this Great Britain is credited with 1135 tons, the Continent, excluding Holland, with 3506 tons, whilst the United States took 9244 tons. According to the statistics of the International Tin Research and Development Council, the world production in January and February was 15,700 tons and 16,000 tons respectively, the total for the first six months of the war being 128,200 tons compared with 61,100 tons in the preceding six months.

Lead and Spelter

The lead market in Great Britain remains unchanged. The supplies of Empire lead coming to hand are sufficient to satisfy the needs of the firms engaged upon war work. Those who require metal for ordinary commercial purposes are not so freely catered for. In the world market dull conditions have ruled and prices have shown a tendency to recede. In the United States the demand has dwindled and although it is said that the producers are well sold and not particularly anxious to obtain new business the steady decline in prices rather indicates the reverse. The quotation now has been further reduced to 5c. per lb. New York. Neutral buyers, however, are not active, for which possibly the British contraband control is partly responsible. In other world markets prices vary considerably and in some cases where a tightness in supplies has developed figures higher than the British or American quotations prevail. The British export drive does not seem to include the lead market since some of the works indicate that they did more business with overseas markets in November and December than in February and March. Other works have plant available for making lead products, but find it difficult to obtain the necessary permits for export. . . . Spelter has been a colourless market for some time and there seems little likelihood of any change developing. The official price is regarded as being moderate and there have been no reports of consumers going short of metal. Consumption is active and on a heavy scale and by far the greater part of the metal is used on armament work. The metal reaching this country is of course entirely of Empire origin, but there is no doubt that if the situation became stringent other supplies could be obtained from Belgium. The brassmaking industry is working full time, whilst the galvanisers continue to take good quantities and as the latter industry is well provided with orders the demand from this quarter may last for some time.

Substitutes for the Use of Ironfounders

In an interesting letter to THE ENGINEER, the Ironfounders' National Committee points out that "users and designers of industrial and domestic plant and equipment are finding themselves handicapped by shortage of, or delay in, obtaining certain ferrous and non-ferrous metals. It may assist them to learn that the ironfounding industry has organised itself to help in the present emergency. During the past twenty years an enormous amount of work has been done to increase our knowledge of the range of materials known as the cast irons, and many of the varieties available have properties not generally associated with cast iron. Almost any metallurgical structure required can be obtained in a wide range of strengths and standard national B.S.I. specifications are available for users, particularly 321/1938 and 786/1938. The industry itself has made great strides in continuous production methods, and generally in the precision of form, uniformity and soundness of the product, and where necessary a wide variety of finishing processes is available. Almost the whole of the raw materials employed are found within the United Kingdom and manufacture is widely distributed. The industry has formed the Ironfounders' National Committee, and information will be gladly sent by me or can be obtained from the chairman of our Technical Committee, Mr. J. G. Pearce, British Cast Iron Research Association, 21, St. Paul's Square, Birmingham, 3. No recommendation will be given unless there is a reasonable likelihood of the substitute material giving satisfactory service, and no charge or obligation will be incurred. For specific cases, it would be an advantage if inquirers could send a print of the part in question, say what it has hitherto been made of and, if working under unusual service conditions (stress, temperature, wear, corrosion, &c.), what life is normally obtained. It is also desirable to know whether conditions permit a measure of re-design."

Control of Ferro-Alloys

The Minister of Supply has made the Control of Chrome, Magnesite, and Wolfram (No. 1) Order. The Order covers chromium and chromium compounds, defined as including any chemical compound of chromium and ore concentrates or residues containing chromium; "magnesite," defined as including natural or manufactured magnesium oxides, hydroxides, or carbonates and dolomite and any mixtures of any of the foregoing, with or without water, and "wolfram," defined as including wolframite, scheelite, and any other ore concentrate or residue containing tungsten. Under the Order the sale and purchase of these materials, wherever situated, will be regulated by a licensing scheme, but a direction issued at the same time under the Order exempts from the licensing provisions everything except chrome ore and concentrates, magnesite costing less than £25 per ton delivered at consumers' works, and wolfram. Power is also taken to require anyone concerned in the handling or treatment of any of the materials referred to in the first paragraph to keep books and records and to produce them for inspection upon demand, and to furnish estimates, returns, and other information as may be required. Mr. N. Isaacs, of the Ferro-Alloys section of the Iron and Steel Control, will act as adviser to the new Control on wolfram. The Order comes into force on April 15th, except as regards wolfram, for which it comes into force on April 8th, on which date wolfram is removed from the ambit of the Iron and Steel Orders by the Iron and Steel (No. 8) Order. Enquiries with regard to wolfram should be addressed to the Iron and Steel Control, Steel House, Tothill Street, London, S.W.1, and for other products to the Chrome Ore, Magnesite and Wolfram Control, Broadway Court, Broadway, London, S.W.1.

French Engineering Notes

(From our own Correspondent in Paris)

Workers' Social Reform

THE Minister of Armament has issued to employers engaged on the production of war material a brochure dealing with the social character of their duties towards workers. It amplifies recommendations he has made from time to time with the object of encouraging men to do their utmost in works and factories for the national defence. What Monsieur Dautry says is a recapitulation of the social programme that has been before employers for the past two years, many of whom had already carried it into effect to a certain extent when the change in the labour attitude showed that something must be done to improve relations between the men and those who employ them. The Minister summarises the nature of these relations by declaring that a man's labour should not be regarded as the personal right of the employer but as of national interest, and that the duty of the employer does not end with the payment of wages. This view of social relations obviously applies to war conditions when labour is mobilised and placed at the disposal of manufacturers. The Minister states his views because it is his duty to see that everything is done to ensure the maximum efficiency of armament production in circumstances where the labour supply is necessarily limited. But they are also views that led to the reform which employers accepted in principle long before the war, when it became evident that labour disturbing influences could only be removed by employers taking a personal interest in the men. There are difficulties in the way of personal contact between the heads of firms and large numbers of workers which it is proposed to overcome by delegating the social work to engineers whose intimacy with workers will enable them to understand the men's outlook and their needs. It is also suggested that women visitors should be trained to make contact with families and give help and advice where necessary. Workers should be made to feel that their interests are looked after all the time. Employers are prepared to do anything that may be required of them within the limits of their financial abilities, and as wartime discipline gives an almost compulsory effect to recommendations it is not improbable that a real effort to put social reforms into practice will begin at once.

Air Services

After the temporary suspension of air services on the outbreak of war the first thing done to restore them was to run all the usual lines to Africa where it had to be shown that France was keeping in close contact with her Empire. The service to Brazzaville, on the Congo, was resumed alternately by the French and Belgian companies. Indo-China was brought again into air communication with the mother country, and no time was lost in resuming the service to South America by way of Dakar. Practically, the Air France system is working normally, except, of course, with Central Europe. The South Atlantic service was pooled with Germany before the war, and Italy is now taking the vacant place in a strongly competitive spirit, while the Dutch K.L.M. company is reported as likely to enter the service with American machines. The French opened up the air route to South America while ocean flights were still in an experimental stage, and their pioneering work was carried out under difficult conditions and at great cost. The French have always regarded the service as their own, and they are now confronted with competitors who are bent upon securing traffic with larger and faster aeroplanes. Air France does not intend to allow the war to interfere with its plans to meet this competition. So far, it has only carried mails which, during the past month, totalled more than four tons. The service is to be improved and accelerated for passenger traffic. At the same time, experimental flights will be continued between France and New York as soon as weather conditions permit of the Azores being used for refuelling. These flights will be made with the new six-engined "Ville-de-Saint-Pierre," and possibly also with "the Lieutenant-de-Vaisseau-Paris," which was built in 1928 and is still good for service. The actual service will be undertaken by seaplanes flying non-stop between the Etang de Biscarosse, south of Bordeaux, and New York. One of the machines is a Potez which is now being erected and will probably undergo trial flights during the summer. It will have six engines totalling about 6000 H.P., and is expected to maintain a cruising speed of 200 m.p.h. The total weight of the machine will be 40 tons. If all goes well the service will be started in the summer of next year.

Inland Waterways

The co-ordination of railways, roads, and inland waterways was suspended on the outbreak of war, and traffic was diverted almost entirely to the railways. They give priority to military requirements and the transport of merchandise suffers in consequence, so that restrictions on road haulage are being relaxed and it is proposed to take fuller advantage of inland waterways which, like the railways, are under military control. Under the co-ordination plan the canals carried about a quarter of the total tonnage of coal and other bulky goods from the Nord and the Pas de Calais, but this traffic has fallen considerably through the requisitioning of barges and the mobilisation of bargemen. The canals are almost entirely electrified for haulage. In normal times the number of barges is limited, and a new barge can only be put into service after the withdrawal of an old one, while a motor barge replaces two hauled boats. This limitation is a serious matter in wartime when the number of barges is reduced by the seizure of boats that happen to be navigating on enemy waterways and much greater transport facilities are needed. During the last war the State partly made good the deficiency in boats by constructing concrete barges, which dropped out of use when they were no longer required to meet an emergency. The State has now placed at the disposal of the Office National de la Navigation a sum of 200 million francs to be advanced to canal users for the building of iron barges. Experience of the past winter, particularly in the supply of coal, shows that the country north of the Loire is far more dependent on inland waterways than in normal times.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Association of Special Libraries and Information Bureaux

To-day, April 12th.—Science Museum, South Kensington, S.W.7. "The Developments of Microphotography in War Conditions," L. Sayce. 5 p.m.

British Association of Refrigeration

Tuesday, April 16th.—Institution of Mechanical Engineers, Storey's Gate, S.W.1. "Refrigeration in the Dairy Industry," H. W. M. Hiron. 6 p.m.

Institution of Automobile Engineers

Tuesday, April 23rd.—Birmingham Centre. James Watt Memorial Institute, Great Charles Street, Birmingham. "Some Problems We Meet," L. H. Dawtrey. 7 p.m.

Institution of Chemical Engineers

Tuesday, April 23rd.—Geological Society's Rooms, Burlington House, Piccadilly, W.1. "A Review of Certain Unit Processes," J. C. Farrant. 5.15 p.m.

Institution of Civil Engineers

Tuesday, April 23rd.—Great George Street, Westminster, S.W.1. "The Remodelling of the Assiut Barrage, Egypt," J. E. Bostock. 5.30 p.m.

Wednesday, April 17th.—N.W. Association. 36, George Street, Manchester. "The Northwich By-Pass," T. A. Proctor. 6.15 p.m.

Institution of Electrical Engineers

Friday, April 19th.—Transmission Section. Waldorf Hotel, Aldwych, W.C.2. Dinner. 7 for 7.15 p.m.

Thursday, April 25th.—Savoy Place, Victoria Embankment, W.C.2. "Thermodynamics and the Coldest Temperatures," C. G. Darwin. 6 p.m.

Institution of Engineers-in-Charge

Friday, April 19th.—Holborn Restaurant, London, W.C.1. Annual Dinner. 6 for 6.30 p.m.

Institution of Locomotive Engineers

Wednesday, April 17th.—Institution of Mechanical Engineers, Storey's Gate, S.W.1. "The Latest Developments carried out in France to Steam Locomotives," Mons. Chan. 5.30 p.m.

Institution of Mechanical Engineers

Saturday, April 13th.—Yorkshire Branch. Chemistry Lecture Theatre, The University, Leeds. "Fifty Years of Marine Engineering," A. L. Mellanby. 2.30 p.m.

Friday, April 19th.—Storey's Gate, Westminster, S.W.1. "The Problems of the Singing Propeller," W. Kerr, J. F. Shannon, and R. N. Arnold. 6 p.m.

Institution of Production Engineers

Saturday, April 13th.—Yorkshire Section. Hotel Metropole, Leeds. "The Electrical Engineer and Production," A. F. Carter.

Institution of Structural Engineers

Tuesday, April 23rd.—Yorkshire Branch. Hotel Metropole, Leeds. "New Developments in Pre-stressed Concrete Construction," T. J. Gueritte. 7 p.m.

Iron and Steel Institute

Thursday and Friday, May 2nd and 3rd.—4, Grosvenor Gardens, S.W.1. Annual Meeting. 10 a.m. each day. For programme, see page 357.

Junior Institution of Engineers

To-day, April 12th.—39, Victoria Street, S.W.1. "Fluid Flow in Pipe Lines and Fittings," S. J. Moore. 6.30 p.m

Saturday, April 20th.—Monico Restaurant, Piccadilly, W.1. Annual Luncheon. 1 for 1.30 p.m.

Friday, April 26th.—39, Victoria Street, S.W.1. "The Construction of High Level Huts in the Alps," R. P. Mears. 6.30 p.m.

Old Centralians

Wednesday, April 24th.—Institution of Mechanical Engineers, Storey's Gate, S.W.1. Annual General Meeting. 5.30 p.m.

Newcomen Society

Wednesday, April 24th.—Science Museum, South Kensington, S.W.7. "The Earliest Industrial Use of Coal," T. T. Read and "A Picardy Post Mill, 1630," Enid and Rex Wailes. 2.30 p.m.

North-East Coast Institution of Engineers and Shipbuilders

Friday, April 19th.—Mining Institute, Newcastle-upon-Tyne. "Modern Joiner Work and Woodworking Tools," A. C. Meredith, and "Decorative Veneers," L. C. W. Jenkins. 6 p.m.

Royal Aeronautical Society

To-day, April 12th.—Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2. "Flight Refuelling," Sir Alan Cobham and M. Langley. 6.30 p.m.

Royal Society of Arts

Wednesday, April 17th.—John Adam Street, Adelphi, W.C.2. "Plastics as Constructional and Engineering Material," H. V. Potter. 2.30 p.m.

PERSONAL AND BUSINESS ANNOUNCEMENTS

MESSRS. LIVESEY AND HENDERSON, Chartered Civil Engineers, Reading, Berks, have taken into partnership Mr. Andrew Brodie Henderson, A.M.Inst. C.E. The style of the firm will remain unchanged.

MR. MICHAEL DEWAR and Mr. F. J. Pascoe, Chairman and Financial Director respectively of British Timken, Ltd., have been elected to the Board of Fischer Bearings Company, Ltd., Wolverhampton.

CATALOGUES

CRYPTON EQUIPMENT, Ltd., North Acton Road, Park Royal, London, N.W.10. Emergency lighting equipment catalogue.

KEATES AND CO. (ELECTRICAL), Ltd., 91, Bishopsgate, London, E.C.2. Brochure on office and drawing office lighting.

BRITISH ROLLING MILLS, Ltd., Tipton, Staffs. Booklet containing particulars on "Brymill" steel and some technical data.

CRAVEN BROTHERS CRANE DIVISION, Ltd., Loughborough. Illustrated folder on large cranes for steelworks and special duties.